ILLUMINATING ENGINEERING

FEBRUARY 1956

In Two Sections
Section 1

◆

Papers on Light Sources
Report on the CIE Zurich Meeting
1955 Progress Report
Lighting Applications

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

WAKEFIELD CEILING

Another Installation

A Wakefield Ceiling Greets Visitors to New Electronics Plant

When a large electrical company built a new plant and research laboratory for the design, development and production of military radar and electronic equipment, it designed the main lobby in contemporary style and topped it with a Wakefield Ceiling.

This is a good example of the use of a Wakefield Ceiling to provide a pleasant seeing-hearing environment in an area where first impressions are important.

Plexiglas diffusing panels distribute the light uniformly throughout the lobby. Acoustical baffles give a high degree of sound control. The whole ceiling is a canopy of light—simple, unobtrusive and in excellent taste.

There is an illustrated brochure on the Wakefield Ceiling which is yours for the asking. Why not write for one today?

THE WAKEFIELD COMPANY
VERMILION, OHIO

WAKEFIELD LIGHTING LIMITED
LONDON, ONTARIO

Lighting by DAY-BRITE makes the big difference...

Retailers sell more when their merchandise is attractively displayed, invitingly lighted. This has been proved over and over, in large stores and small, modernized with Day-Brite lighting. It makes the big difference in sales—customers linger longer, come back oftener, buy more . . . When you invest in lighting, don't compromise. Insist on Day-Brite—designed and built for long-life service. Before you decide, see your Day-Brite representative—look for him in your classified phone directory. Or, send for store-lighting data.

Nation's largest manufacturer of commercial and industrial lighting equipment

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

Day-Brite Lighting, Inc.
5432 Bulwer Ave., St. Louis 7, Missouri

Lighting for Sales

Day-Brite PLEXOLINE is the base of a complete store-lighting system, combining related elements. Linear sections and circular ACCENT units that are complete in themselves. When used in combination, unlimited lighting patterns are possible—curves, circles, angular arrangements.

PLEXOLINE linear sections are designed for surface mounting, but can be suspended. ACCENT units are furnished in both fixed and adjustable types for spot lighting.

PLEXOLINE linear section

ACCENT unit, fixed

ACCENT unit, adjustable

One of many typical store-lighting arrangements

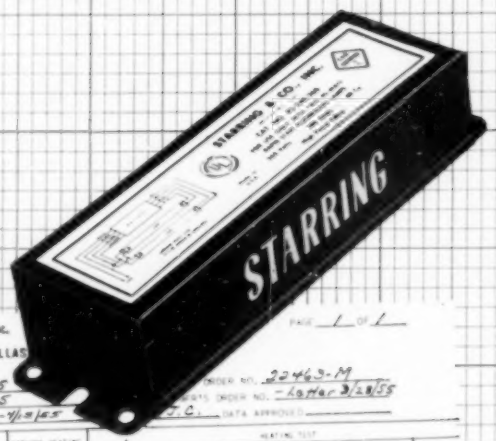
61107

CONTINUING LEADERSHIP

Starring **RS-240-260** Ballast

for two 40-Watt Rapid-Start lamps on 240-280-Volt circuits with a nominal rating of 265 Volts.

High Power Factor, of course. And it's CBM-Certified to meet the requirements of Supplement 2 to ASA Specification C82.1.



RS-240-260
8 3/16" x 2 13/16" x 2"
Mounting Length 8 3/16"
Weight 5.3 pounds

Starring Ballasts are Engineered into Leadership

Ask for our Complete Catalog

STARRING & COMPANY, INC.

1600 SEAVIEW AVENUE • BRIDGEPORT 8, CONNECTICUT

EDison 4-0108

ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

February 1956

Vol. LI, No. 2

In Two Sections
Section I

1955-1956 Officers

President
R. F. Hartenstein

Vice-President
M. N. Waterman

Vice-President
Kirk M. Reid

General Secretary
George J. Taylor

Treasurer
J. S. Schuchert

•

Editor
Ruby Redford

•

Advertising Manager
Clayton E. Ellis

•

Assistants
Barbara Lamson, Editorial
Adelaide Philiba, Advertising

•

Publications Committee
J. S. Schuchert, Chairman
Brooks Chessaing
H. F. Davidson
Aileen Page
J. A. Schneller

•

Executive Secretary
A. D. Hinckley

Technical Director
C. L. Crouch

Contents

159 Russell C. Putnam — Applied Principles at Case Institute of Technology

166 Sylvester K. Guth — Comfort in Lighting, A Report on Discussion at the C.I.E. Zurich Meeting

169 Discussion — Daylight Measurements in Six New England Schools, Willard Allthin

171 I.E.S. Lighting Data Sheet — Series XXI
Lighting a School Business Practices Room (13-80)

173 Lighting Progress in 1954-1955

197 Georges Destriau — On the Effect of Various Metal Electrodes on Brightness Waves in Electroluminescence

203 I.E.S. Lighting Data Sheet — Series XXI
Lighting a Low Ceiling Classroom (13-81)

205 Charles W. Jerome — Effect of Bulb Wall Temperatures on Fluorescent Lamp Parameters

214 Horace H. Homer, Keith H. Butler, Martha J. Bergin — Phosphor Stabilization for Better Lamp Performance

221 I.E.S. Home Lighting Data Sheet
Lighting a Kitchen with a Slanted Ceiling (22-51)

223 Stanley M. Segal — Elongated Carbon Arc Sources

8A TELECAST — Lighting News of Current Interest
Lighting Calendar, 13A; About People, 18A; Books and Pamphlets, 21A; It Seems to Me, 22A; New Members, 22A

30A New Equipment Data

38A Index to Advertisers

Sustaining Members — Latest listing appeared in January 1956 issue of ILLUMINATING ENGINEERING.

I.E.S. Committee Personnel — 1955-1956. Listing appeared in the December 1955 issue of ILLUMINATING ENGINEERING. Revised listing will appear in the April 1956 issue.

STATEMENTS and opinions in articles and papers in ILLUMINATING ENGINEERING are the expressions of contributors and do not necessarily represent the policies or opinions of the Society. Official Society opinions are expressed only in official committee reports specifically approved by the Council of the Illuminating Engineering Society.

ILLUMINATING ENGINEERING SOCIETY

EDITORIAL and advertising offices
1860 Broadway, New York 23, N. Y.

PUBLICATION office 32d Street & Elm Avenue, Baltimore 11, Md.

Founded 1906

ILLUMINATING ENGINEERING: The Journal of the Illuminating Engineering Society. Copyright 1956 by the Illuminating Engineering Society. Published monthly in the United States of America. Entered as second-class matter at the Post Office, Baltimore, Md. Acceptance for mailing at special postage rates provided for in Section 1103 P.L.&R., Act of October 3, 1917. Authorized July 16, 1918. ¶ Subscription $12 per year plus extra postage to all countries to which second-class postage rates do not apply; single copies $1.00. ¶ Address changes must be received at I.E.S. headquarters by the first of the month to be effective with the issue of the next succeeding month.

Section of the executive offices White Motor Co., Cleveland, Ohio. Architect, Dalton-Dalton & Associates. Contracting electrical engineer, Anton Eichmuller. Electrical contractor, Hatfield Electric. "Lucite" extruded by The Southern Plastics Co., Columbia, South Carolina. Recessed luminaires by The Wakefield Co., Vermilion, Ohio.

Better looking, better lighting

with diffusing panels of Du Pont LUCITE®

The new offices of the White Motor Company in Cleveland have been designed to combine high functional efficiency with unusual attractiveness. As far as lighting is concerned, diffusing panels of "Lucite" play an important role in this "dual-purpose" design.

Diffusing panels of extruded "Lucite" acrylic resin transmit optimum light without specular glare or shadow. They are strong, durable, free from discoloration, and dimensionally stable. Installation is a simple matter. Panels of "Lucite" are light in weight and easy to handle.

Extruded "Lucite" can be formed readily into desired shapes and is available in a wide range of transparent and translucent colors. For further information on how you can incorporate "Lucite" into your lighting designs write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 282, Du Pont Building, Wilmington 98, Delaware.

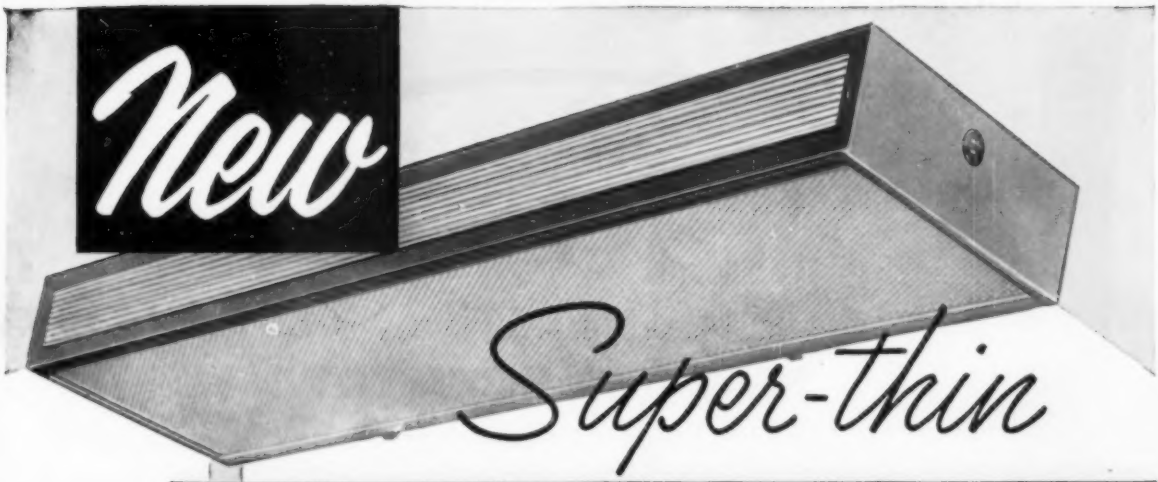
Quality Controlled

This "Quality Controlled" label may be used only by qualified extruders of Du Pont "Lucite" acrylic resin. It assures the lighting industry that the extruded material conforms to standards for low shrinkage and uniform caliper established by E. I. du Pont de Nemours & Co. (Inc.).

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



New Super-thin VERSA-LUX

Curtis Versa-Lux is a versatile beauty. Super-thin, Versa-Lux is in perfect cadence with new low ceiling designs, harmonizing with any decorative motif. Units available with a molded polystyrene plastic egg-crate louver, three different Holophane Controlenses—6016, 9016 and 9033-9034—or Corning Alba-Lite ribbed diffusing glass panels and plastic or glass side panels. All metal parts finished baked white "Fluracite" enamel.

This original Curtis design is as practical as it is beautiful. Just 3⅞" thin and 12" wide, Versa-Lux will replace a 12" ceiling tile, so that it can be partially recessed, mounted directly to the ceiling, or pendant hung, in continuous lines or individually.

The door is supported by three steel hinges on which it may be lowered or completely removed without the use of tools. Three turn latches securely hold the door in position. Clear plastic hinges and turn latches are used with the plastic egg-crate louver.

Architects, designers and engineers seeking a unit for performance, versatility and beauty are making this newest Curtis luminaire their unanimous choice.

For complete illustrated data on the Super-thin Versa-Lux, write Dept. 841-VL.

CURTIS LIGHTING, INC.

CURTIS LIGHTING, INC.
6135 West 65th Street
Chicago 38, Illinois

IN CANADA
Curtis Lighting of Canada, Ltd.
195 Wickstead Ave.
Leaside, Toronto 17, Ont., Canada

GET BETTER SIGHT WITH CURTIS LIGHT—MILLIONS DO!

Standards Published by I. E. S.

"AID OUR INDUSTRY"

Says Utility Vice President

". . . the lion's share of the credit for selling Maplewood, Mo. adequate street lighting goes to your own Illuminating Engineering Society. I.E.S. worked with the American Standards Association and established ILLUMINATION LEVEL figures for street lighting.

"These figures gave Maplewood a goal. Without such a target, a standard established by reputable authority, I doubt that any of us who did the job would have gained nearly as much business as we did."

From speech by Mr. Dudley Sanford, Executive Vice President, Union Electric Company of Missouri.

Whether it be Street Lighting, School Lighting, Industrial, Residential, etc., I.E.S. works for the entire lighting industry. Contribute to the I.E.S. Sustaining Membership Research Fund to insure improved standards for the lighting of tomorrow.

SUSTAINING MEMBERSHIP COMMITTEE OF ILLUMINATING ENGINEERING SOCIETY, 1860 BROADWAY, NEW YORK 23, NEW YORK

Applied Principles . . .

at Case Institute of Technology
Electrical Engineering Building

By RUSSELL C. PUTNAM

In this building student illuminating engineers learn the principles of their profession — in an environment which applies those principles.

LIGHTING FOR THE William E. Wickenden Electrical Engineering Building of Case Institute of Technology is of special interest to illuminating engineers and educators. It is particularly fitting that this building is dedicated to Dr. Wickenden because early in his career he was a member of the Illuminating Engineering Society, a professor of illuminating engineering, and the author of a book on that subject.* He later gained world-wide recognition for his contributions to engineering education as president of Case.

The faculty of the electrical engineering department worked closely with the architects in the design of the building, so that the best arrangement of physical facilities and equipment could be obtained. In the design of the lighting, the author had a free hand (within the limits of the budget) to specify light sources, luminaires, lighting layouts and such correlated items as the reflectances of ceilings, walls, floors, and furniture. This was an unusual privilege seldom given to a professor by a college, and the result was an opportunity to combine a well lighted building with a demonstration of good illumination practices and a working laboratory to be used for courses in illuminating engineering.

The lighting of each laboratory, classroom, office and corridor has been carefully designed to meet the specific needs of the room, to illustrate an application of certain lighting principles, and to show the various means of furnishing the desired lighting by current good practice. With approximately 100 rooms in the building, having varied visual tasks, an opportunity was presented for a wide variety of types of installation. Accordingly, 29 different types of luminaires from 13 different manufacturers are employed and both fluorescent (rapid start, slimline, low brightness) and incandescent lamps are used.

The building presented a real challenge to obtain efficient and visually comfortable lighting because of the low ceiling height of 9 ft 10 inches with 8 ft in the corridors. This is met on the first three floors by recessed fluorescent luminaires using luminous ceiling elements and various types of troffers. The fluorescent luminaires on the fourth floor are suspended while incandescent lamps, mainly of the silver bowl type, are used on the fifth floor.

Because of the large number of different types of installations, mention will be made in this article of only a few of the more interesting ones. The building is entered through a large lobby (Fig. 1) which is lighted by flush mounted plastic luminaires which may be changed in pattern and lighting level according to the occasion. A suite of executive offices adjoins the lobby where the illumination is furnished by semi-luminous ceilings where luminous elements 8 feet square are set in a border of acoustical ceiling (Fig. 2). These offices

AUTHOR: Professor of Electrical Engineering, Case Institute of Technology, Cleveland, Ohio.

*Wickenden, William Elgin: *Illumination and Photometry*, McGraw-Hill, New York, New York, 1910.

Figure 1. The lobby, where the flush mounted plastic luminaires give an attractive pattern.

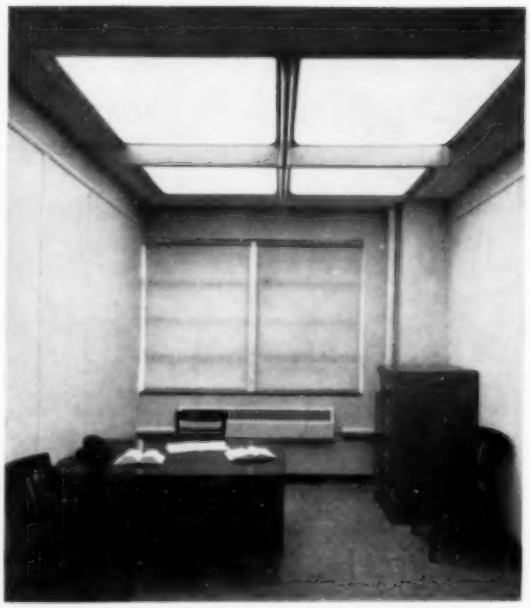


Figure 2. (above) A semi-luminous ceiling furnishes this office with forced ventilation through the perforated beams, and 55 footcandles of well-diffused illumination.

Figure 3. (left) This lecture hall features thyratron control for dimming the fluorescent lamps. A lighted chalkboard is behind the sliding panels.

Figure 4. Troffers arranged in a grid pattern and containing low-brightness T-17 fluorescent lamps operating on three phases reduce shadows, reflected glare and stroboscopic effect to a minimum in this electrical machinery laboratory. Lighting level averages 80 footcandles.

ENGINEERING BUILDING
AT CASE INSTITUTE OF TECHNOLOGY

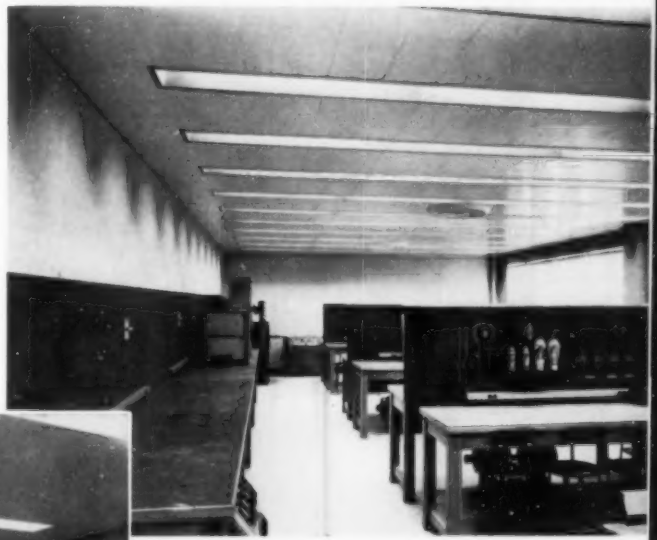


Figure 5. An exceptionally comfortable brightness pattern for the ceiling is provided by these deep aluminum troffers with single low-brightness T-17 fluorescent lamps.

Figure 6. Glazed troffers with rapid start lamps equipped with special ballasts to reduce radio interference, average more than 70 footcandles in the laboratory.

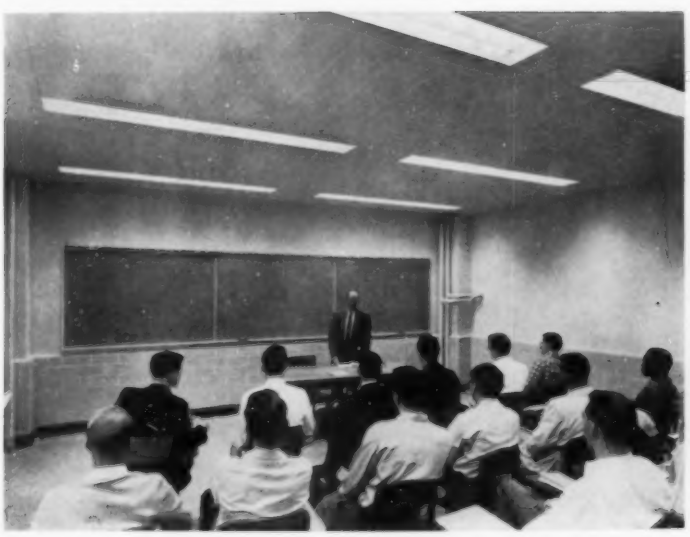


Figure 7. This classroom averages more than 50 footcandles with 30 on the chalkboard.

Figure 8. The arrangement of the luminaires here gives averages of 45 footcandles on the chalkboard and 60 on the horizontal writing areas.

Figure 9. (above). This library is comfortable with well-selected reflectances and more than 60 footcandles on the desk and tables.

Figure 10. (right) Even illumination in the corridors and on the lockers is furnished by this fluorescent installation.

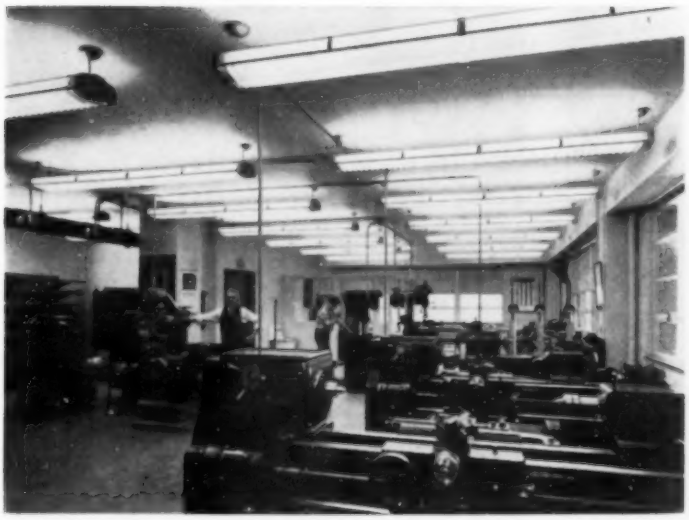


Figure 11. Averages of more than 75 footcandles on the machine tools in this shop are comparable to office conditions in quantity and quality.

Figure 12. (above) Silvered bowl incandescent equipment furnishes 45 footcandles to this small laboratory.

Figure 13. (right) A classroom in the electrical communications area uses silvered bowl luminaires.

Figure 14. Refracting glass luminaires in the corridors in the electrical communications area directs light to the wall lockers.

Figure 15. Louvered troffers are well suited for the lighting of these photometric spheres.

Figure 16. The corridor which also serves as a photometric room for testing projection equipment.

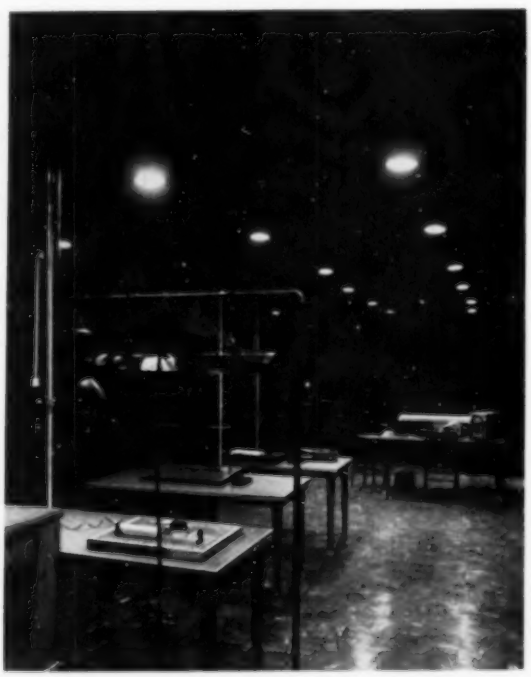


Figure 17. The folding walls are partially removed in this photograph to illustrate the conversion of several small photometric rooms into a large laboratory.

are ventilated by bringing the air into the cavity of the luminous ceiling and then to the room through the perforated beams. Thyratron control for dimming the fluorescent lighting system is a feature of the air conditioned lecture hall (Fig. 3). This gives a range in lighting level from 55 footcandles to less than one-half footcandle so that the illumination can be varied smoothly at the will of the lecturer to suit the requirements of the moment. A fluorescent lighted chalkboard appears when the sliding wall panels are removed. All lecture rooms, classrooms, and laboratories are connected with a closed circuit television system, with the outlets appearing in this room on the wall in the rear of the platform.

The large electrical machinery laboratory (Fig. 4) eliminates shadows as far as possible by an installation in a grid pattern of recessed aluminum troffers, each troffer containing two low brightness, T-17, 60-inch fluorescent lamps. The low brightness lamps reduce reflected glare from the faces of the instruments and with lead-lag ballasts operating on three-phase circuits there is no noticeable stroboscopic action of the rotating machinery. The lighting level in this laboratory averages 80 footcandles.

The industrial electronics laboratory (Fig. 5) also uses the low brightness, T-17, fluorescent lamp in single lamp troffers to give an exceptionally comfortable brightness pattern on the ceiling and lighting levels of 50 footcandles on the work areas. Another electronics laboratory (Fig. 6) utilizes glazed troffers with the ballasts of the rapid start lamps equipped with special filters to cut down on radio interference. The illumination in this laboratory averages more than 70 footcandles.

Typical classrooms are shown in Figs. 7 and 8. In the first the louvered recessed troffers give an average of more than 50 footcandles in the room, and 30 footcandles on the chalkboard. In the latter room the arrangement of the suspended, louvered, direct-indirect luminaires gives a well balanced illumination of 45 footcandles on the chalkboard and 60 on the horizontal writing areas. The library (Fig. 9) also averages more than 60 footcandles on the desks and tables. The illumination in the corridors (Fig. 10) is very even from the louvered continuous fluorescent equipment with more than 25 footcandles on the face of the wall lockers. The lighting of the departmental shop (Fig. 11) gives more than 75 footcandles distributed over the machine tools from office type louvered slimline units.

The fifth floor is used for communications, microwaves, networks, acoustic laboratories, etc., so that the problem of radio interference from fluorescent lamps would be serious. Incandescent light sources are, therefore, used throughout this floor, in most cases luminaires utilizing the silver bowl lamp, as illustrated by this laboratory (Fig. 12) and this classroom (Fig. 13). Incandescent units are also used for the corridor on the fifth floor with a refracting glass enclosure which directs light to the wall lockers (Fig. 14).

Case has included illuminating engineering in its curriculum continuously since 1905. This year there are 64 junior electrical engineers in the class which includes lectures and laboratory periods. Although divided into sections, a large space is necessary to handle this many in laboratory work, along with graduate and research activities, and so a third of the space on the second floor is devoted to illuminating engineering. One section is devoted to the integrating spheres and general classroom activities (Fig. 15) while the major part of the laboratory is turned over to photometric rooms. Fig. 16 shows the corridor with ten individual darkrooms opening from it. The corridor is arranged so that it too is a photometric room as it is built so that it can be used to photometer searchlights, airplane landing light, etc., which require a 100-foot distance or more. The lighting units in this corridor, as well as in the photometric darkrooms adjoining are all mounted so that they can be moved at will or easily taken down if they interfere with the tests. The individual photometric rooms are separated by means of modern folding walls so that they can be used either individually, or as many as six rooms combined as one large room. Four of these rooms with the intervening walls removed are shown in Fig. 17.

All the footcandle values given in this article are based on readings taken at night after ten months of operation. In general, the lighting levels in the offices, classrooms, and laboratories on the first four floors (fluorescent lighting) range from averages of 45 to 85 footcandles while those on the fifth floor (incandescent equipment) vary from 30 to 45 footcandles.

Dr. T. Keith Glennan, president of Case, reports that he often gets two comments from men who have seen the building: "isn't the lighting fine" and "why didn't you make up your mind." He appreciates the fact that because we "didn't make up our minds" this building is a unique and valuable teaching tool. Students, practicing engineers, and architects can study these various lighting installations as practical solutions of specific visual problems typical of educational environment. It is our hope that the lighting of this building at Case Institute of Technology has contributed to the progress of the profession.

Comfort In Lighting

A Report on Discussion at the C.I.E. Zurich Meeting

By SYLVESTER K. GUTH

In some respects, meetings of the International Commission on Illumination (C.I.E.) are not very different from our own I.E.S. Technical Conferences. In terms of the many discussions of comfort in lighting this was very definitely so. We started with a preconference meeting, continued with informal discussions whenever two or more of us got together, and then ended up with the formal secretariat session. There was, of course, good reason for these many meetings. This was the first time in four years we had such an opportunity and it would be four more years before another would be available. With any subject in which there is international interest — and diversified opinion — it is important to have personal discussions in order to be able to arrive at a meeting of minds.

At the Stockholm meeting of the C.I.E. in 1951 it was recommended that "member nations should examine all new experimental data to determine whether it is possible to adopt standards of practice for desirable, or permissible, brightness relationships." Subsequently, in the reorganization of technical committees, a new Secretariat was established and assigned the topic, "Estimation of Comfort in Lighting." The Secretariat duties, including the responsibility for preparing a report, were allocated to the Australian National Committee.

The terms of reference — or charter — of this Secretariat are:

1. A study of the factors influencing comfort in lighting, including the methods of measuring the effect on comfort of such factors and the assessment of their relative importance.
2. The establishment of qualitative and quantitative conditions (derived from the above factors) to provide comfort in lighting, and the presentation of such data in a form suitable for practical purposes.

These terms obviously are very broad and, as was to be expected, a number of diverse opinions and viewpoints were expressed at the meeting. In fact, there were two schools of thought. One group included scientists and engineers whose primary interest is the elimination of discomfort. The other group, composed of architects and designers, is concerned with the aesthetic contributions to pleasure. A contributing factor to this cleavage of opinion was that in some of the European countries the term *comfort* is associated with aesthetics rather than with what generally are considered negative aspects of light and lighting. This illustrates that one of the major problems at international meetings is the language barrier; exact translations of meaning are not always easy to obtain.

While it may have appeared to some observers that the two groups were far apart in what each felt was the heart of the problem, all agreed that the ultimate objective was to formulate general rules for desirable and livable visual environments. The question to be resolved was which should come first and receive major emphasis, aesthetic considerations or factors producing discomfort. Not much could be accomplished until it was agreed that both were important, would be studied and ultimately brought together. This simple statement of agreement did not come quickly nor easily, but was the result of much discussion.

The suggestion of the Secretariat was adopted: The immediate task is the correlation of existing knowledge on discomfort due to glare and the preparation of a method of evaluation which has international acceptance. It was felt that there was no reason to delay this step while the more abstract psychological and aesthetic aspects of the overall problem were being developed.

The Secretariat Report provided a starting point for most of the discussions. It was a summary of the replies received from various National Committees to a comprehensive questionnaire on the estimation of comfort in lighting. In brief, it covered:

Definition of comfort
Factors influencing comfort
Methods of studying comfort
Direct discomfort glare
Reflected glare

Two appendices described suggested forms for

A report made before the National Technical Conference of the Illuminating Engineering Society, September 12-17, 1955, Cleveland, Ohio. AUTHOR: General Electric Co., Nela Park, Cleveland, Ohio.

presenting discomfort glare information in a simplified and useful manner.

As I have already indicated, considerable time was devoted to the discussion of the definition of comfort and the factors which influence it. The decision to confine ourselves to the *elimination of discomfort* was a wise one. It permitted us to concentrate on the immediate problem of evaluating the available experimental data, analyses and methods of presentation. The greater portion of the report was devoted to these.

The main question at hand was to determine whether we could develop from the experimental data a formula and a method of presentation that will be simple and applicable to practical design. It was recognized that only a complex formula can adequately represent the relative effects of the many factors which are involved. Experimenters and others have suggested several forms which many felt were too difficult to use. Since most typical lighting installations involve a relatively limited range of luminous areas, it was believed that a more or less simple formula would be feasible. A possible one could be

$$G = \frac{B^2 \omega}{F} f(\theta) f(S)$$

in which

G = discomfort rating
B = source brightness
ω = size of source (steradians)
F = field brightness
$f(\theta)$ = factor for position of source
$f(S)$ = factor for brightness of immediate surround of source

The exponents were derived by Hopkinson after an evaluation of the experimental data obtained by a number of investigators. This is similar, but not identical, to the Harrison-Meaker formula. The factor $f(\theta)$ is to be derived from the Luckiesh-Guth position indices; and $f(S)$, which is complex and not too well established, can be derived from some new (unpublished) work by Hopkinson and Petherbridge. Values of G would be related to the multiple criterion method used in the Petherbridge-Hopkinson studies and range from 24 for "just imperceptible" to 3000 for "just intolerable" glare criteria. The borderline between comfort and discomfort (BCD) for an average observer corresponds to a discomfort rating of about 270.

Everyone did not fully agree with the glare formula as proposed, but most indicated their willingness to try it. It was pointed out that oversimplification could result in considerably over- or underrating the discomfort of a lighting installation. For example, we probably would have to retain the two modifying factors for source position and brightness of immediate surround of source. Furthermore, if the range of source sizes is great, it will be necessary to use a more representative formula such as the one developed by Luckiesh and Guth. Such complexity should not be a deterrent to the use and application of discomfort information. If necessary, special nomographs and charts can be devised to facilitate calculations.

In the application of this formula to a complete lighting installation, direct additivity of individual discomfort ratings is to be assumed. We all recognized that this was not strictly true and some modification would have to be introduced. One new possibility was outlined in a paper which I presented at the C.I.E. Several alternative suggestions were made, but they all require further experimental verification to determine which will be most suitable.

The use of an arbitrary numerical rating has not been found very satisfactory. Therefore, it is proposed to apply a probability function similar to the Visual Comfort Index (VCI) which will indicate the percentage of people who will not be expected to be uncomfortable. At the moment, the choice of a scale has not been agreed upon. Hopkinson found that inexperienced observers appeared to be less sensitive to glare than experienced observers. On the other hand, our BCD experiments indicated no such consistent difference. Putnam and Faucett substantiated our results by finding that the personal history of exposure to brightness, especially natural outdoor brightnesses, seemed to govern to a large extent the sensitivity of the individual.

It was universally agreed that some sort of tabular presentation of discomfort ratings was necessary. Such tables must be in a form that will be most useful to those who are concerned with lighting design. Two types of tables are being considered. One of these will be similar to those developed by Harrison and Meaker and presenting the ratings in terms of VCI. Some objections were raised to this method because of the large number of tables that would be necessary. It was questioned whether every luminaire manufacturer could be expected to supply such tables. In certain countries the illustration of a limited number of typical luminaires may provide guidance, but it was doubted that this would apply at the international level.

An alternative mode of presentation could be a table of limiting brightnesses for various room dimensions and mounting heights. These limits would correspond to a predetermined discomfort

rating or visual comfort index. Incidentally, this method is under consideration in Australia and is incorporated in a draft of a new lighting code. A correction curve or table could be provided to indicate the limiting brightnesses for higher or lower degrees of discomfort. An important objection to this type of presentation is that a single brightness limitation is prescribed for a given set of room dimensions regardless of the position of the source. That is, the same limiting brightness would be specified for all viewing angles and zones.

Each type of table has certain advantages and disadvantages. Only some experience can help us determine which is preferable. Since both types of presentation would be based upon the same formula, they would be, in effect, presentations of the same thing in different forms. In other words, each country could select the one deemed most suitable for its particular purposes.

At the formal meeting of the Committee it was recommended "that the C.I.E. should undertake the preparation of international tables for the evaluation of direct discomfort glare, and that it should examine the various possible modes of presentation of such tables, having regard to the considerations set out in the Secretariat Report." It was further recommended that, if the principle of working parties is agreed, this first resolution be referred to such a group. A "working party" is to be a relatively small group of experts who are thoroughly familiar with the technical and scientific aspects of a specific problem. Certain other committees will continue to be designated as Secretariats whose main function will be to prepare reports of lighting progress in various countries.

Before anyone becomes unduly apprehensive that we shortly will have C.I.E. glare or comfort tables, may I reassure him that this is an exploratory step. It is, in effect, what Ward Harrison did a number of years ago when he published his provisional glare factor tables, but doing so on an international basis. The only way by which any glare evaluation method can be checked it to try it and compare calculated values with subjective appraisals. A number of modifications will, in all probability, be necessary before any final tables are agreed upon by the various National Committees of the C.I.E.

To officially recognize the importance of all environmental factors, an additional resolution was approved: "That if the principle of working parties is agreed, a further working party be set up to study the problems of Pleasantness of Lighting; provided that the two working parties work in close cooperation and that they share a substantial common membership." Thus, both important and major viewpoints in the field of Comfort in Lighting will be covered during the next quadrennium.

From the brief review of our discussions in Zurich, I'm sure you'll agree that we have moved forward on an international basis. As Ward Harrison pointed out, we gain a great deal by personal exchange of ideas and information. Misunderstandings are cleared up and we have a better appreciation of the other fellow's point of view. I think it is very significant that the Europeans are feeling encouraged to try a glare evaluation method not too greatly different from the one that has been quite successful over here. Everyone is willing to do this with an open mind and with the hope that an internationally acceptable method ultimately will evolve from this community effort.

DISCUSSION

G. G. Rae:* Dr. Guth's paper indicates that further advances are still being made in the important subject of Visual Comfort Appraisal. It is interesting to note that a proposed formula, evaluating a "glare number" would include a term, F, to the first power in the denominator instead of F to the 0.44 power as in the present formula employed by Dr. Guth. This F, representing adaptation brightness, is a very important element in the formula and, if it is assumed that the term relating the position of the lighting units in the field of view and the term relating luminaires to background brightness are not intrinsically dependent upon F, a change in the exponent of F has a most appreciable effect on the glare number.

For example, if the adaptation brightness is 20 footlamberts and if the glare number on the basis of the older formula is 50, the new formula would produce a glare number of only 9. The writer feels that Dr. Guth's VCI method produces theoretical comfort appraisals that are somewhat lower than reported by actual observers.

A modification in the basic formula itself of the type proposed would bring calculation and observation into closer accord.

Sylvester K. Guth:** A specific lighting system will be assigned different glare numbers depending upon the formula that is used. However, one cannot alter the comfort-discomfort sensation by using a different formula. In other words, the numerical assessments of 50 and 9, given by Mr. rae, are indexes obtained by two different rating systems to express the same sensation. Relatively, they have the same equality as 212 F and 100 C.

In discussing the ratio between luminaire brightness and field brightness, Mr. Rae neglected to take into consideration that in the proposed formula brightness B is squared, whereas in the BCD formula it is to the first power. The new formula can be represented by

$$G = \frac{B^2}{F} f(\omega, P, S)$$

*Holophane Co., Inc., New York, N. Y.
**Author.

and the BCD formula by

$$M = \frac{B}{F^{0.44}} f(\omega, P, S)$$

If we assume that $f(\omega,P,S)$ are the same in both, G and M are proportional to ratios between B and F. It is evident that $F^{0.44}$ is approximately equal to the square root of F. Hence, for all practical purposes, M is equal to the square root of G. Nevertheless, the significance of the two glare numbers must be identical because they refer to the same lighting system.

Such confusion between glare numbers obtained with different formulas emphasizes the need for relating them to a common Visual Comfort Index.

Daylight Measurements in Six New England Schools

(Discussion of paper by Willard Allphin, published October 1955 ILLUMINATING ENGINEERING)

E. W. CONOVER:* This paper presents some factual data that is of extreme interest to daylight engineers, architects and school boards. The author should be highly commended for his efforts and his ability to secure the cooperation of the teachers and pupils throughout the school year.

A study of this paper indicates the need for more observations than reported. For example, the reflectances of all surfaces are given excepting that of the ceiling. This is an important factor for utilization of daylight reflected from the ground as well as that from light directing glass block. Another example is that the position of roller shades for the tests as well as customary practice is stated for the Central School, Salem, N. H., but no mention is made of the conditions for the drapes in the West Parish School or the venetian blinds in the North School and the Central School Addition.

Table I giving the summary of the readings taken is good evidence that daylighting will provide the minimum footcandle requirements over most of the time. We were particularly impressed with the 31 per cent of the time for values of 0 to 30 footcandles. A further check made omitting the Fiske School, which had 30 footcandles or below 63 per cent of the time, would make the average of the other five schools 25 per cent of the time when values would be below requirements. This is all the more remarkable since none of the schools had all reflection factors within the range specified as desirable in the American Standard Practice for School Lighting.

We too are of the opinion that both daylighting and electric lighting systems have a place in school lighting. It is difficult to understand why anyone would recommend installing an electrical system that would not provide the minimum requirements alone. In fact, adequate wiring should be provided to carry a greater load as a glance through previous recommended requirements indicates that the minimum may be raised before the building is too old.

*Detroit Steel Products Co., Detroit, Mich.

J. W. GRIFFITH:* The data presented in this paper are very interesting. It is most unfortunate, as the author pointed out, that the data should not be used to compare one type of daylighting system with another. Proof of this can be obtained by comparing the dark days of North School at Chelmsford, Mass., with the dark day of Central School Addition, West Acton, Mass. The sky brightness readings are in favor of the North School by 100 footlamberts and the fenestration area is greater. The interior decorations and the test desk location are similar; however, the illumination on the test desks for the Central School is almost twice that of North School. This only accentuates the extreme need for a standard testing and reporting technique for daylighting as well as artificial lighting installations. Had the author taken the exterior illumination from below the horizon, from above the horizon excluding the sun, and from the sun alone for each fenestration area instead of the sky brightness, the installations could be compared with other daylighting installations.

Table I would have been more impressive had the accumulative per cent of total reading been used for readings over 30 footcandles as well as those below 30 footcandles. It would seem to me that since the variation in footcandles across the room is much lower on dark days than on the average, the higher values in Table I are representative of more desks than are the low values.

It is unfortunate that the American Standard Practice for School Lighting does not call for a minimum of 30 footcandles illumination on the desk from the artificial lighting alone and from the daylighting for average conditions alone. As was pointed out in the paper by S. K. Guth,[1] 50 per cent of a group require considerably more illumination than the minimum value based on average groups. To verify the need for higher levels of illumination, you can walk into almost any classroom where the minimum daylight illumination is about 30 footcandles, and you will find that the students or teacher will have the artificial

*Southern Methodist University, Dallas, Texas.

lights burning. This is not a desire to waste money, but a desire to have higher levels of illumination. It is interesting to note that if each of these schools had an artificial lighting installation of 30 footcandles minimum, the teacher and students could have had a minimum illumination of 50 footcandles or above over 80 per cent of the time.

1. Guth, S. K.: "Footcandles for the Forgotten Man," to be published.

R. W. McKinley:* I agree with Mr. Allphin that "in-service" data are "proof of the pudding!" I will take this opportunity to suggest that alternate conclusions or at least additional conclusions can be drawn from his findings:

Better coordination of daylight and electric design is possible and offers some promise of maintaining better lighting conditions at any given budget level. For example — for daytime occupancy spaces, why not provide two to three times the electric illumination over the "darkest" area than over the "lightest"!

Also, why not be *sure* that the 30-footcandle level is maintained by providing automatic controls and relieving the teacher of this chore!

I believe and I think that Mr. Allphin agrees, that the underlying problem is not electric light *vs* daylight but rather engineering *vs* no engineering.

Eric Pawley:** I applaud Mr. Allphin's paper. I think it is time that these two things — daylight and manufactured light — be brought to work together. In passing I might comment that it seems a horrible example of the exploitation of child labor!

R. A. Boyd:*** I felt that I had to make a comment on this paper because it more or less confirms what we have discovered at our Daylighting Laboratory at the University of Michigan through our experimental classroom that has become known as the Classroom of Tomorrow. Last year a paper was published in Illuminating Engineering, entitled, "The Daytime Lighting of School Classrooms," and through that investigation we found that 80 per cent of the time one had better than 30 footcandles of illumination and consequently required the electric lighting only 20 per cent of the time, if you were considering such a classroom only for daytime use. So it is of great consolation to me to find that this is more or less in agreement.

Bernard Greene:† The author's approach is most stimulating as it helps to establish the relation between good daylighting and manufactured lighting for the classroom. So often either one or the other is ignored when treating either subject. It is interesting to note from the data and the way in which they were presented, that in all but one of the schools investigated 30 footcandles of daylight was obtained over 73 per cent of the time. Presumably by the choice of the daylighting arrangements in the economics of the problem, higher illumination over greater periods of time would have to be obtained to have these levels.

Willard Allphin:†† The author thanks all the discussors and will attempt detailed comments only where questions have been raised. In reply to Mr. Conover, all the ceiling reflectances were apparently in the range of 75 to 80 per cent. Actual measurements should perhaps have been made and reported, but it did not seem that the necessary balancing on stepladders would produce any additional value to the reader of the paper.

With regard to the availability of daylighting data, I would just like to say that the Daylighting Committee is investigating this problem and in the process of compiling data as to the availability of daylighting in different parts of the country. The contribution of the learned students who took these data should be of great help in correlating the information which we are getting together.

Where window shades were not mentioned, there were none. Of those having shades, only the Central School, Salem, N. H., seemed to have a standard practice of operation. In other cases the operation was haphazard, and to ask for a daily report on the positioning would have been to influence the results.

If the suggestions of Mr. Griffith for outdoor measurements had been available as a standard procedure, such measurements might have been included in the project, but it is difficult to see how this would have permitted a direct comparison of the schools. The rooms still differ in size, shape and reflectances.

Mr. McKinley raises the question of automatic controls. There has never been more than a limited interest in these on the part of those who specify or buy school lighting. The rather high cost cannot be the answer, because very little interest was shown in the low-cost and effective substitute demonstrated in the Bowditch Model Classroom.[1]

No doubt the reader realizes that Mr. Pawley smiled when he spoke of the exploitation of child labor. Actually, as might be expected, the children enjoyed the chore, and the teachers retained their customary cheerfulness. In two fifth grade classes the teachers made science projects out of looking up illumination matters. In another case the superintendent of schools wrote a publicity release about the project and it appeared in several newspapers.

1. Allphin, Willard: "Brightness Control in a Modern Schoolroom," Illuminating Engineering, Vol. XLI, No. 1 (January 1946).

*Pittsburgh Plate Glass Co., Pittsburgh, Pa.
**Research Secretary, American Institute of Architects, Washington, D. C.
***Daylighting Laboratory, University of Michigan, Ann Arbor, Mich.
†Consulting Engineer, New York, N. Y.
††Author, Sylvania Electric Products, Inc., Salem, Mass.

I.E.S. Fiftieth Anniversary

Features are planned for future issues of I.E., during the Anniversary year of 1956, on the significant developments since 1906 in the fields of Photometry, Outdoor Lighting, Transportation Lighting, Signal Lighting, lighting for Television production and the history of Trade Associations.

INSTALLATION AT KEARNY HIGH SCHOOL, KEARNY, NEW JERSEY.

Lighting a School Business Practices Room

LIGHTING OBJECTIVE: To illuminate a classroom to produce an environment representative of high quality business office interiors.

GENERAL INFORMATION: The high school business practices classroom shown above measures 48 feet 6 inches by 22 feet 6 inches. Ceiling height (floor to plastic) is 10 feet and the structural ceiling is 24 inches above the plastic. Surface characteristics are as follows:

ceiling		
cavity above plastic	white	85% RF
equivalent reflectance of luminous ceiling		70% RF
acoustic baffles	white	80% RF
walls	yellow and green	55-60% RF
door	natural	45% RF
draperies	multicolor	30% RF
floor	multicolor	35% RF avg.
furniture	natural	45% RF
working surfaces	natural	45% RF

All of the furniture was built by members of the school's maintenance force.

(over)

A.I.A. File No. 31

Figure 2. View of room from opposite end.

INSTALLATION: Continuous rows of 96-inch T-12 standard cool white 425 ma slimline fluorescent lamps are installed on 41-inch centers 19⅜ inches above the plastic luminous ceiling. The channels and plastic ceiling are manufactured by Luminous Ceilings, Inc., Chicago, Illinois. After approximately 250 hours' operation the average general illumination was 52 footcandles.

Brightnesses were as follows:

ceiling	
luminous ceiling (at 45°)	99 ft-L
acoustic baffles	34 ft-L
walls (1 foot below ceiling)	23 ft-L
door	6 ft-L
draperies	16 ft-L
floor	22 ft-L avg.
furniture (sides)	13 ft-L
working surfaces	30 ft-L

Lighting designed by Clyde L. Nordheimer, P.E., 520 North Wyoming Ave., South Orange, N. J. and Robert M. Hannan, Lighting Representative, Public Service Electric and Gas Co., 271 North Broad St., Elizabeth, N. J.; installation made by the Kearny Board of Education Electrician; furniture specially designed by S. Dan Zeppenfeld, Secretary and Businss Manager, Kearny Board of Education.

Lighting data submitted by Robert M. Hannan, Public Service Electric and Gas Co., Elizabeth, N. J. and Arthur F. Whitley, Lighting Representative, Public Service Electric and Gas Co., 80 Park Place, Newark, N. J. as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Series XXI 2-56

Lighting Progress in 1954–1955

Prepared by the Committee on Progress of the Illuminating Engineering Society

This is the Illuminating Engineering Society Progress Report for the year 1954-1955: the theme is "Light and Life." Actually, life itself is made possible through the light that falls on growing plants, so light is life. Our interest lies especially in light and lighting, in illuminating engineering. Life in America as we know it today and increasingly throughout the entire world could not exist without modern lighting. The goods we produce, the things we learn and see and enjoy, and life in the modern home, all depend upon the availability of abundant, pleasant and effective lighting.

The use of man-made light has grown so enormously that in the year 1955 thirty times as much light (that is, lumen hours) was produced and consumed in the United States as thirty years ago in the year 1925. The principal reason for this growth is that the lighting is better. It is more adequate, more comfortable, more effective, more economical, and it is more beautiful. It is chiefly for these reasons that people are using light more fully. They install more and better lighting and they use it more extensively.

It is largely because we in the Illuminating Engineering Society meet and exchange ideas that better and better lighting is available. We establish standards of lighting that act as an inspiring guide to the whole world. In the past practically all phases of lighting have been studied and reported upon by Illuminating Engineering Society lighting committees resulting in reports, guides, or standards for lighting factories, stores, homes, schools, offices, modes of transportation and other fields.

A report presented at the National Technical Conference of the Illuminating Engineering Society, Cleveland, Ohio, September 12-16, 1955. Approved by the I.E.S. Council, December, 1955

It should be noted that the Progress Committee does not pose as an authoritative body on the matter of lighting practice. Rather this report is to be taken as a measure of progress in lighting.

COMMITTEE ON PROGRESS

E. W. Beggs, *Chairman*

C. L. Amick, *Vice-chairman*

Hugh F. Carroll	Merle Keck
O. P. Cleaver	Howard F. Kingsbury
Kurt Franck	James McCulloch
John Gornet	J. A. Meacham
B. F. Greene	T. C. Sargent
Arthur R. Jaeger	R. P. Teele

H. A. Williams

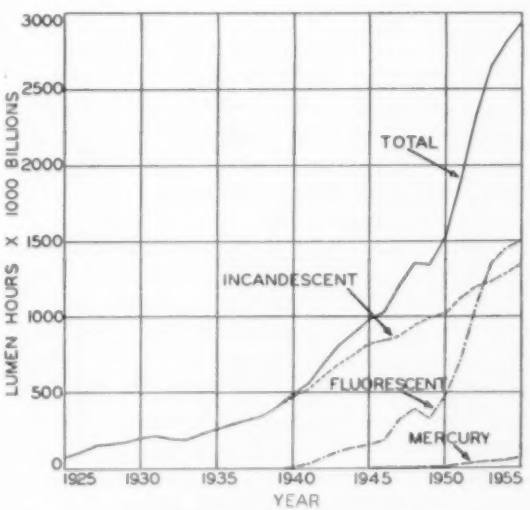


Figure 1. The growth of lighting in America as shown by the increasing production of lumen hours per year.

Progress in . . .

Light Sources

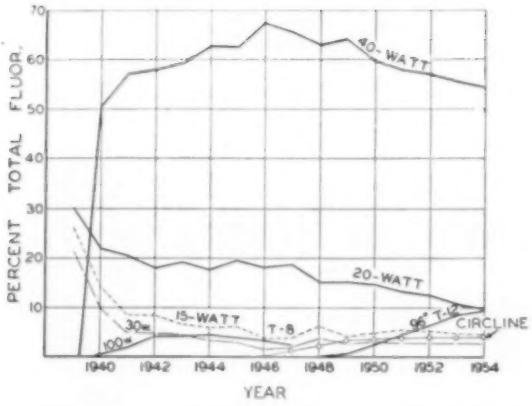


Figure 2. Demand by type of fluorescent lamps showing predominance of 40-watt and recent growth in use of 96-inch T-12 slimline. Most new 48-inch T-12 installations use the rapid start lamp.

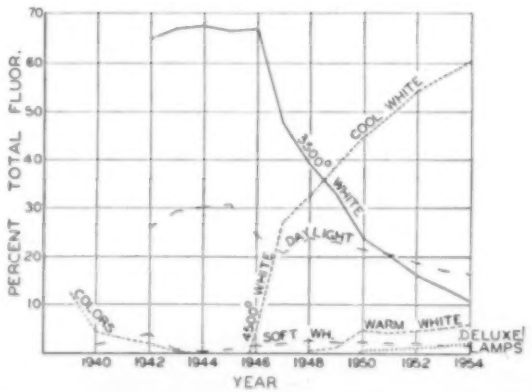


Figure 3. Demand by color of fluorescent lamps. Cool white is in greatest demand particularly in new lighting equipment. (Deluxe lamp curve is for either cool or warm white lamps.)

We now live in the atomic age. The atomic explosions have produced light and radiation almost too intense to be described, and in illuminating engineering there are no suitable units to measure it. While, as yet, there is no thought of using atomic fission as a source of illumination, some day this may be done. The atom bomb is the brightest man-made light source so far and perhaps for all time.

In the field of practical light sources the fluorescent lamps have taken over the leadership in amount of light produced by artificial sources in this country. Recently manufacturers have reported improvements in high output lamps which should reduce overall lighting costs for general indoor applications. At the same time the increased light output of these new sources under low temperature operating conditions and lower outdoor starting voltage requirements, means excellent performance for exterior applications. The 96-inch T-12 high output lamp recently became available in deluxe cool white and deluxe warm white. They provide good color rendition without sacrifice of illumination when compared with the same number of units using 425 ma slimline fluorescent lamps in standard cool white and standard warm white. The 48-inch T-12 and the 72-inch T-12 high output lamps were made available in standard cool white and standard warm white.

Filament lamps continue to play important roles in industrial and office lighting. The latest R-bulb is a 1000-watt R-52 or R-57 lamp, mainly used for high bay industrial lighting where lamps and external reflectors are relatively inaccessible and difficult to clean and maintain. The 1000-watt R-52 is a heat resistant bulb and is a companion to the previously available 500- and 750-watt regular glass lamps. The 1000-watt R-57 supplements the previously available 550- and 800-watt lamps.

There is a new 20-watt 24-volt or 48-volt R-12 incandescent lamp used for telephone trouble service and a new 250-watt R-40 brooder lamp specifically designed for farm use. A 12-volt truck headlamp was developed to withstand the unusual shock and vibration imparted by certain heavy Diesel powered trucks. This lamp has a ceramic bridge or shock absorber through which the lead wires are threaded thus preventing the filaments from touching and "shorting" under conditions of excessive shock.

Many important additions were made to the growing family of PAR lamps. A 200-watt PAR-46 medium flood lamp provides a substantially rectangular beam pattern which is used for store lighting and general outdoor floodlighting. Also in a similar pattern a new 300-watt PAR-56 flood lamp is a companion to the previously available narrow spot and medium flood lamps. Quite recent-

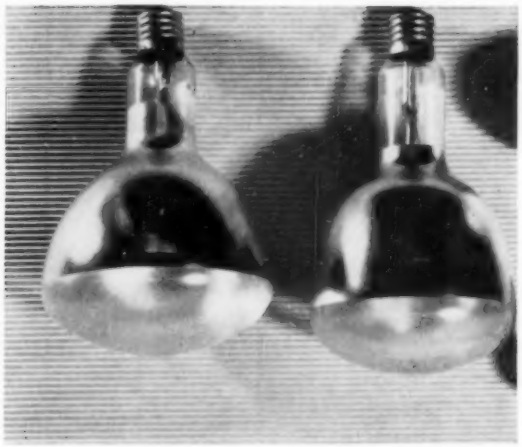


Figure 4. Reflector incandescent lamps now available in 1000-watt size in both R-57 (left) and hard glass R-52 type (right); R-57 for economy; hard glass to eliminate hazard of water cracks.

ly a 500-watt PAR-64 narrow spot lamp was announced, and it is expected to find many applications.

For "scoop" units in television studios 750-, 1000-, and 1500-watt PS-52 lamps have been developed with inside silica-coated bulbs. This eliminates the need for spun-glass covers over the front of the "scoops." Another lamp mainly developed for television studio use was a new base-down-to-horizontal burning 750-watt T-20 lamp, which permits greater flexibility in the aiming of Fresnel theatrical-type units.

In the photolamp field a new 3-letter code was developed under American Standards Association auspices to aid in positive identification of photolamps. The M-2 photoflash lamp was improved in light output, made more uniform and more reliable. A new photoflash lamp has been made which is still smaller than the M-2. Originally produced for surreptitious copying of maps, documents, etc., in true cloak and dagger style, it can be coated with an infrared transmitting lacquer to permit excellent close-up pictures to be taken with infrared film in complete darkness.

Another photographic source is the radio frequency lamp. A disk of refractory material becomes incandescent when bombarded by radio frequency induction. In film printing and projection machines the extremely uniform light emitter permits direct use of the target image, giving four times faster printing speeds.

Two new tubular quartz infrared lamps have been developed. One is the 25-inch 2500-watt lamp

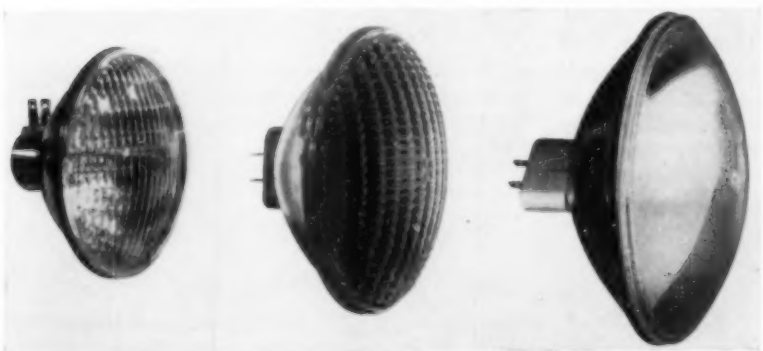


Figure 5. New "PAR" lamps. Left, 200-watt PAR-46; center, 300-watt PAR-56; and right, 500-watt PAR-64.

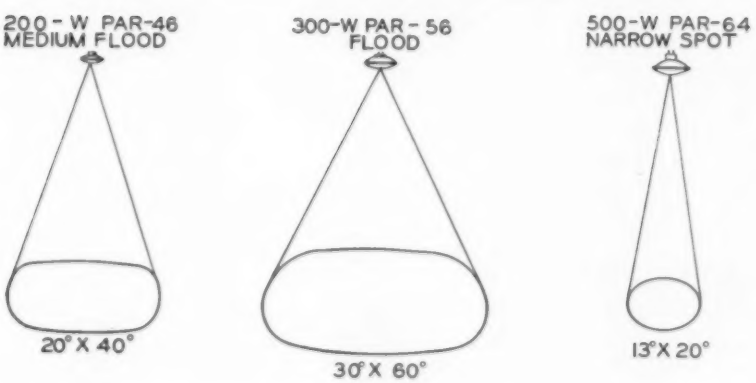


Figure 6. Light beam patterns of new "PAR" lamps.

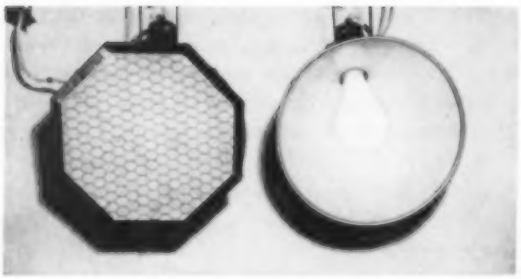


Figure 7. Inside silica white coated bulb provides soft light without spun glass diffusers.

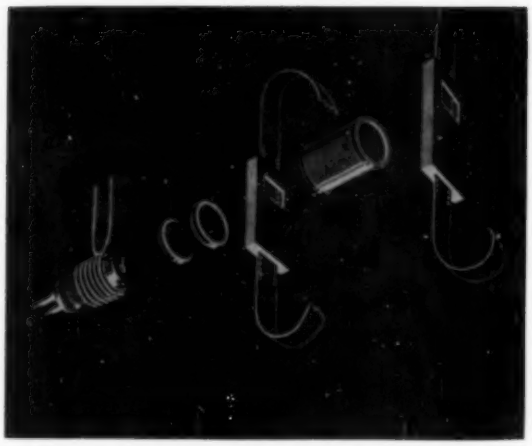


Figure 8. Radio frequency excitation makes refractory disc become a light source for film printing and picture projection service.

for 460-500 volts, and the other is a 50-inch 5000-watt lamp for 920-1000 volt circuits. Both lamps are available either in clear or sand T-3 quartz bulbs.

A new line of 400-watt and 1000-watt weatherproof heavy-duty mercury and fluorescent-mercury lamps, suitable for outdoor and indoor use, has been announced. The lamps will resist mechanical breakage and glass cracks due to the elements *i.e.* rain, snow. Some manufacturers are making guarantees to cover the full rated life of mercury lamps, and important increased light output and life ratings have been announced on various types of 400-watt mercury lamps.

A new 6.6-ampere A-H24 mercury lamp has been designed particularly for straight series street lighting operation without individual ballasts. This lamp is rated at 20,000 lumens and looks very much like the E-H1 lamp except that the arc tube is of slightly different dimensions. It is available for trial installations.

The 1000-watt mercury xenon lamp has been redesigned. The feature of the design change is the reflectorized coating which covers slightly less than one-half of the bulb. Its purpose is to increase the heating effect at starting time, thereby obtaining more light immediately and full light output more quickly. When the lamps are turned on about 25 per cent of the final light output of the lamp is immediately produced. This is the lamp used in the new Navy 12-inch searchlight.

The American Medical Association shield of approval is no longer the safeguard for the public on sunlamps. It meant that the lamp, such as the RS sunlamp, was not only safe, *i.e.* radiated no shorter

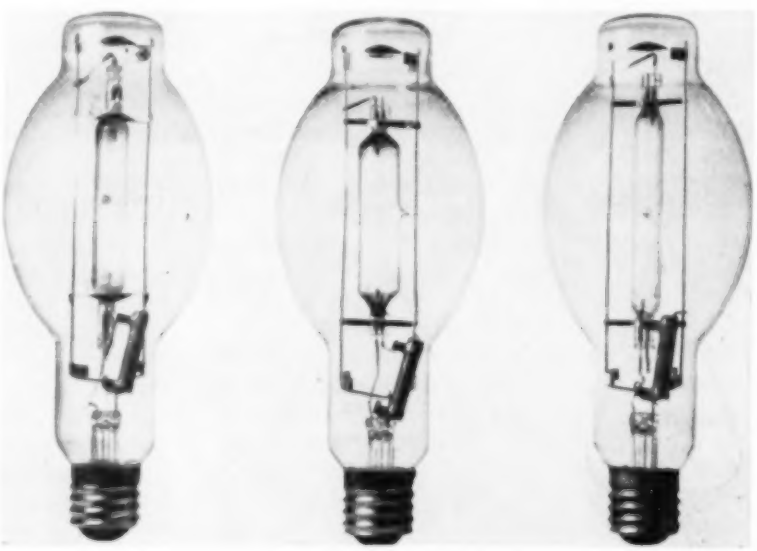


Figure 9. Family of three 20,000 lumen mercury lamps. The 6.6-ampere lamp for straight series operation has a larger diameter shorter arc tube, shown in the middle lamp. Standard E-H1 on the left and new 425-watt A-H17 on the right are shown for comparison.

rays than the sun, but that it was adequate and effective. Now that the American Medical Association has discontinued policing sunlamp manufacturers must tell their story to protect the public.

The newest sources in the field of bactericidal lamps are those that generate 1849A rays in addition to the 2537A rays that kill germs. These shorter rays are the radiations that change the oxygen of the air (O_2) to ozone (O_3) and are used widely to destroy undesirable odors.

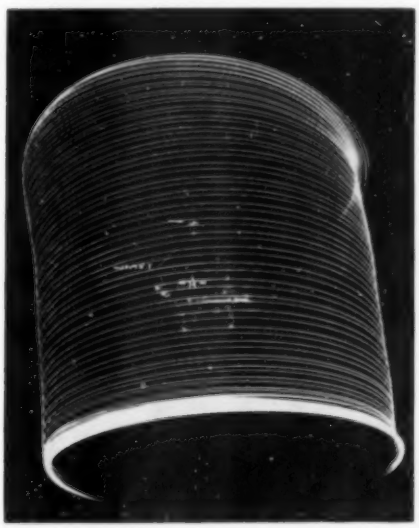


Figure 10. (Above) Night manoeuvering of helicopter is made practical by new blade tip lights. Special high strength lamps were developed to withstand tremendous centrifugal forces.

Figure 11. (Left) Filament supporting system of special helicopter lamp prevents distortion at 1000 "G."

In the miniature lamp field a new internal filament supporting system for the helicopter blade tip lamp resists a distorting centrifugal force of 1000 times the weight of the filament coil. A new baseless flashlight lamp finds application in indicator service where high temperature would destroy basing cement.

New searchlight developments are revealed for military service. An experimental circuit is capable of operating 1000-watt and 2000-watt short-arc mercury lamps, either continuously or pulsing them to five kilowatts once every minute for ½ second and three seconds respectively. The peak beam candlepower when using the two-kilowatt lamp is 80 million, and when pulsed to five kilowatts the peak beam candlepower increases approximately 2½ times for either lamp. The lamp is mounted in a drum which utilizes an 18-inch mirror to produce a two-degree beam spread.

A new experimental a-c carbon arc searchlight consumes 1200 watts at 20.5 volts and will operate on either 50, 60 or 400 cycles. The brightness of the arc crater is 250 c/mm^2 producing 10 x 10^6 peak beam candlepower and a beam spread of three degrees using an 18-inch diameter mirror with a focal length of six inches. The searchlight operates unattended for ten hours with a 30-second interruption every two hours during automatic reloading. Seven-millimeter positive carbons are used with an angle of 24 degrees between them. The carbon consumption is 4-inches/hour/electrode.

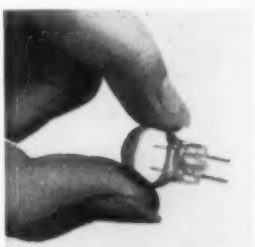


Figure 12. (Right) Baseless flash light bulb — simpler in structure — eliminates basing solder and cement.

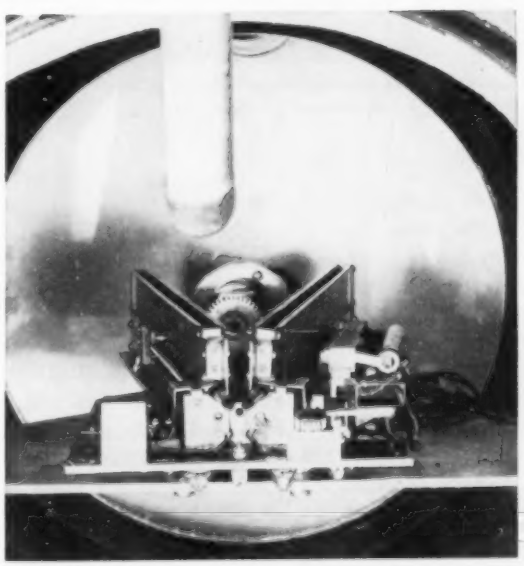


Figure 13. Close-up of new experimental AC carbon arc mechanism which operates 10 hours unattended.

Figure 14. Twelve-inch signalling searchlight with new xenon mercury lamp now being used for communications, navigation and rescue service.

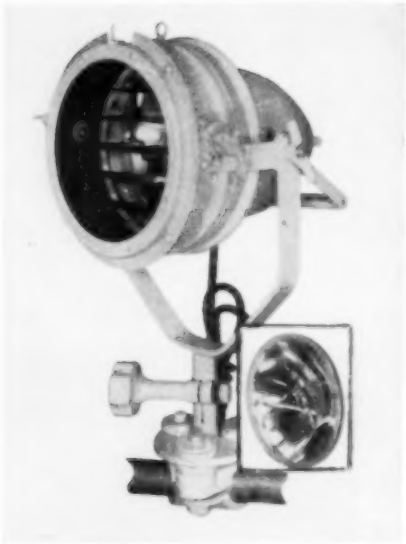


Figure 15. New 150-watt xenon lamp in PAR-64 bulb hand "hand-held" signalling and searchlight use.

Figure 16. Gas discharge type colored navigational light developed by U. S. Navy.

Two signalling searchlights have been developed for the Navy. One is a mercury arc 12-inch signalling searchlight — a standard Navy searchlight converted to use a 1000-watt short arc mercury xenon lamp in lieu of the 1000-watt projection type incandescent lamp. The maximum beam candlepower has been increased from 150,000 to 6,000,000. The other searchlight is an xenon arc 8-inch signalling searchlight — a standard Navy searchlight converted to use a 150-watt xenon lamp in lieu of a 100-watt incandescent lamp. The xenon lamp is mounted at the focus of a PAR-65 bulb and the maximum beam candlepower has been increased from 50,000 to 200,000.

A new gas discharge type colored navigational light consists of a low-pressure gas discharge lamp coiled into a compact helical form and mounted in a watertight transparent enclosure. The colors (red and green) are produced by combinations of gases and phosphors. These lamps, replacing the incandescent lamp and colored filter combinations, are smaller, lighter in weight and provide greater luminous efficiency. Their low current drain also permits operation on batteries where required.

Recent field studies of lighting systems for industry and streets show serious need for group replacement of mercury lamps. Since mercury lamps last far beyond the average life rating generally given to the lamps by the manufacturers, the studies show that group replacement or systematic replacement should be recommended and this is receiving considerable attention. Many people are faced with the problem of removing old dim lamps before they actually burn out. No single answer can be given to the question of how and when group replacement should be practiced. In general, however, it is advisable in most instances to change the lamps at somewhere between 6000 and 8000 hours.

European light source development emphasizes fluorescent and mercury types, in general revealing an interesting and valuable amount of interchange between the old and new worlds. Fluorescent colors are not internationally standardized yet but indications are that we are all getting closer together. Europeans at present express relatively more interest in deluxe colors and improved color renditions.

Progress in . . .

Lighting Measurement

During the past year an improved circuit for measuring the microvolt output of radiometers was described. This circuit permits measurement of radiation of lower values than was possible before this equipment was devised. A light-weight direct-reading capacitance resistance analyzer for ballast circuits has been announced; and a new precision converter from a-c to d-c now enables users to measure a-c voltages to 0.05 per cent.

A cosine-corrected illumination meter, designed at the Engineering Research Institute of the University of Michigan, is now commercially available in single or double units for use indoors or outdoors. A new specularity meter has been developed in which the light reflected twice by the test specimen is passed through an aperture to give a response proportional to the square of the reflectance.

We have new tools to let us work more accurately and a number of our older ones have been improved during the year. Groups of standard lamps representing the photometric units have been sent out of the United States to the Bureau International des Poids et Mesures where they will be intercompared with similar standards from the national standardizing laboratories of other countries. This will enable uniformity in measurements of luminous intensity and luminous flux throughout the world.

Much research is being done in the school lighting field and the School Lighting Committee has some extremely important studies underway. One objective is to determine the effect of reflected glare on the visibility of a number of common school tasks and a preliminary report was made a few months ago. Two valuable compilations of the literature on school lighting have been published; one, made at the University of California, in Los Angeles, is a review of the basic research on this subject and is entitled "Visual Data for School Lighting." Both publications verify the fact that we are just beginning to get into the problem of creating comfortable and efficient visual environments in schools.

A new photometric laboratory has been established in the Rocky Mountain Region.

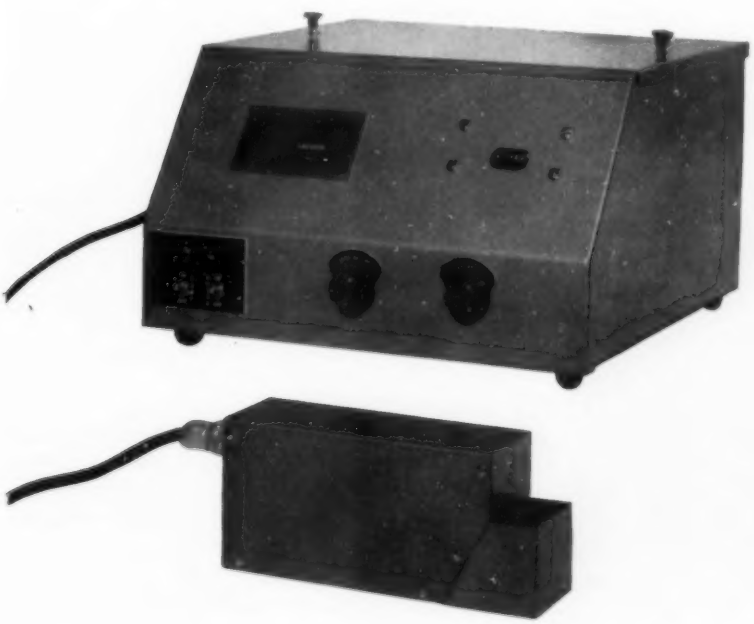


Figure 17. Automatic photometric unit for measuring specular reflectance for all surfaces including formed reflectors.

What's New in . . .

Lighting Materials and Equipment

Continued progress in accessories for fluorescent lamps is seen in the introduction of new design starters which give longer life to 40-watt preheat type fluorescent lamps on the lead circuits of many lead-lag ballasts. Regular glow switch starters permit voltage surges which frequently instant start the leading circuit lamps, with subsequent loss in lamp life. But the new glow-switch, thermal-glow and thermal starters virtually eliminate early lead-lamp failures. Other fluorescent accessory developments include smaller ballasts for two important lamps. The two-lamp 40-watt rapid start ballast has been made lighter and smaller, the smaller case allowing slimmer more modern units and the scrapless punchings saving ballast material. The new ballasts for the 96-inch and 72-inch slimline fluorescent lamps are only 1¾ inches high, a reduction during the year of nearly ⅞inch. Thinner compressible lampholders for medium bi-pin and slimline bases were made available, and lampholders of the "end-mounted" and tunnel types were listed for both indoor and outdoor service.

New plastic face signs use flashing 40-watt rapid start lamps. While tests of lamp performance are not complete, there is evidence that acceptable service life can be achieved with ballasts specifically designed for flashing service. There are white-finish ballasts for use with plastic signs, which minimize the shadows which a black ballast might cast.

Push-pull lamp holders now take up less space. New designs of reduced thickness are available for bi-pin, single pin and recessed contact base lamps reducing the dead space between lamps.

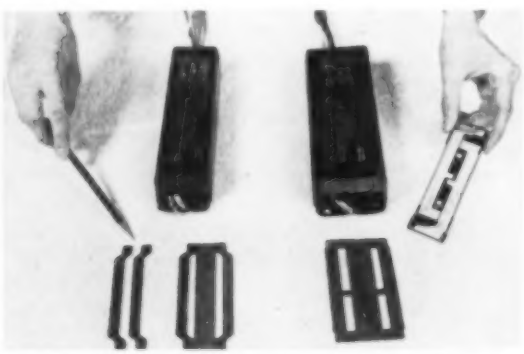
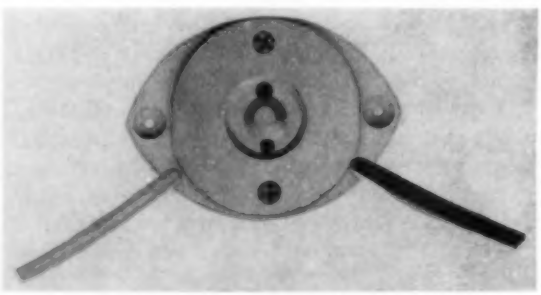


Figure 18. Comparison of new small size and old 40-watt rapid start ballast.



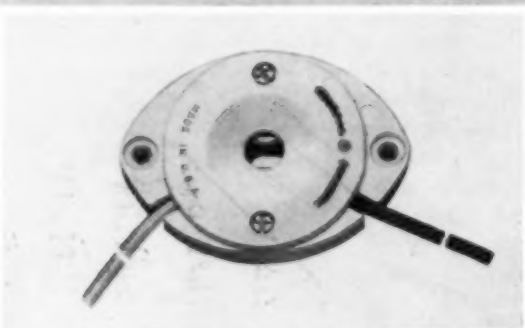


Figure 20. Thinner compressible lamp holders for "end-mounted" and tunnel types now available for indoor and outdoor service to reduce dark space between lamps.

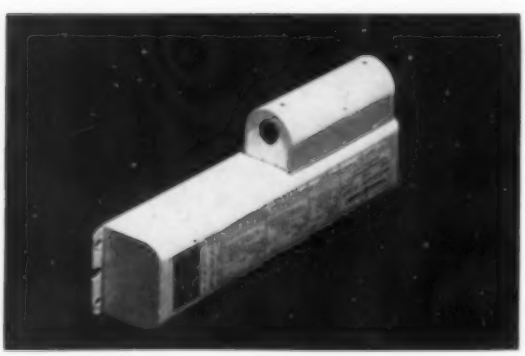


Figure 19. White enamelled ballast for use with signs improves brightness uniformity of illuminated plastic.

Figure 21. (Left) Explosion-proof light for operating photoelectric cells and associated elements.

Figure 22. (Right) Industrial explosion-proof floodlight particularly useful for hazardous locations outdoors.

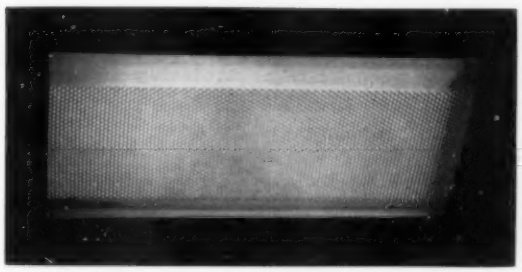


Figure 23. (Below, right) Low brightness lens panel for fluorescent equipment, showing two types of prisms.

More and more people are installing the 25 per cent upward-component industrial units and more manufacturers are in the process of making these units, each one achieving the same results in a different way. In the incandescent field a hazardous-location unit has been introduced. It is the first to have Underwriter's Laboratories approval, employing conventional type of construction without requiring the complete unit to be carried outside of hazardous areas for relamping. In addition to the unit the complete system of switches, junction pieces and conduit fittings is available.

One unusual development is an explosion-proof unit to project a beam of light for operation of photo-electric cells and associated elements. Another new unit in the field of industrial lighting is an explosion-proof floodlight. It was designed primarily for use in aircraft maintenance, and aircraft refueling operations as well as for emergency lighting at refineries, distilling plants and plants where industrial dust is a hazard.

A new low-brightness lens panel for fluorescent equipment was introduced during the past year. The panel is unique in that it uses two different types of prisms to obtain the extreme low-brightness lens. In the side prisms there is a uniform down bending action on light that might otherwise escape at higher angles. The pyramidal prisms in the panel center section concentrate light from the tubes and reflectors at an angle below the glare zone.

A manufacturer of ceiling materials is making available a series of translucent panels for use with their ceilings. An unusual feature of these luminous panels is that the panel is fabricated of two formed units facing each other and bound together around the perimeter by dielectric welding. A specific volume of air is contained between the units and the diaphragmatic damping with this air space provides the sound absorption value, thus producing a luminous ceiling with sound absorption qualities.

An unusual incandescent unit with a prismatic reflector and a concave bottom has been designed for use in offices, stores, libraries, etc. The bottom of the unit has a lens 15½ inches in diameter. The outstanding feature of the unit is that the outside of the glass reflector is covered with a specially designed fiber-glass cover which produces a soft glowing appearance of the outer portion of the unit.

The main feature of a new commercial-type unit is the application of a complete diamond type plastic lens which is 12 inches wide by 48 inches long. This is the first time an injection-molded lens of this size has been used in a lighting unit. Other new commercial-type units, utilizing plastic to a large extent, have been developed. One of these is a completely plastic, enclosed unit. The entire shielding is made of one piece injection-molded plastic which is available in white, green or coral tint (the colors are formulated in the plastic at the time of molding). Another new unit is of the in-

Figure 24. Incandescent unit with prismatic reflector, concave lens and fibre glass cover.

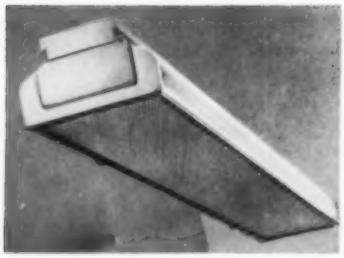


Figure 25. Commercial type unit with one-piece injection-molded acrylic diamond lens panel.

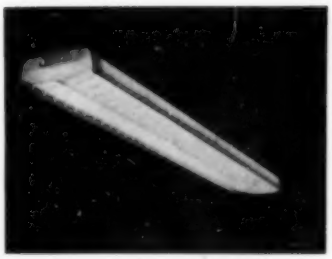


Figure 26. Complete plastic enclosed unit. Entire shielding made of one-piece injection molded plastic.

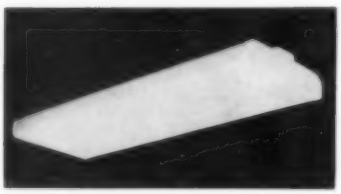


Figure 27. Semi-indirect type unit with small hinged plastic basket type enclosure.

Figure 28. (Above) Surface-mounted thin unit with center island for ballast enclosure.

Figure 29. (Right) This 2000-watt spotlight for large theatrical and television applications provides oval-beam pattern readily adjustable from the floor.

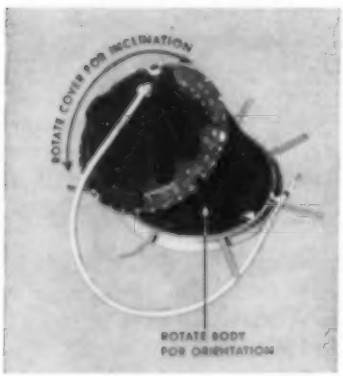


Figure 30. New recessed spotlight provides prefocus adjustment by means of peephole and rotating plate.

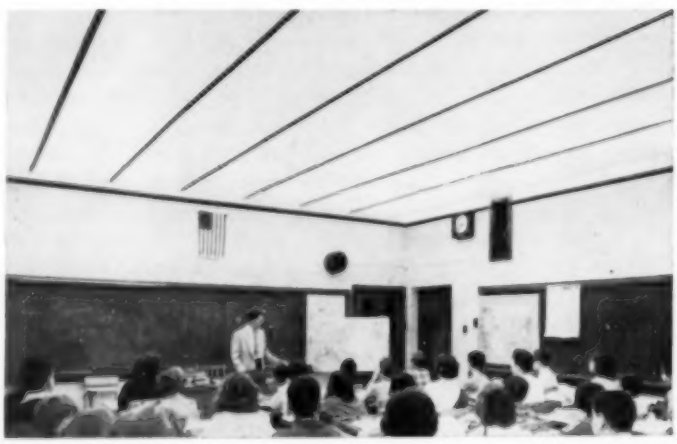


Figure 31. (Above) Luminous ceiling which comes in packaged units suitable for any room.

Figure 32. (Left) Neutral low-transmission clear glass which screens out excessive brightness and glare.

direct type (75 per cent uplight and 25 per cent downlight) which utilizes a shallow hinged plastic basket type enclosure.

Decreasing the depth of units has been the aim of some manufacturers, one of whom has brought out a surface-mounted unit only 2⅝ inches deep. This depth was obtained by creating an island in the center of the unit which not only adds to its decorative appearance but also encloses the ballast.

Among other structural material items announced this year is a new material combining glass and aluminum. It is manufactured by combining the aluminum honeycomb design with standard window glass, thus producing a multiple purpose architectural material possessing a high impact strength, excellent bending and compressive qualities, at a weight considerably less than solid glass panels. This material has been used in exterior and interior walls, partitions for room dividers, skylights, stores, etc.

In the stage lighting field there is a new 8-inch 1000-2000-watt Fresnel spotlight which compresses its light beam into an oval of three to two. As before, the light beam remains variable from spot to flood focus, but in each position the oval pattern retains its dimensional ratio. The spotlight is used in large theatrical and television applications for front, side and back lighting. This spotlight is equipped with a tilting hook for setting azimuth and elevation, and focus hooks for obtaining desirable spot or flood characteristics. A lightweight aluminum pole with a hook on the end is used to grasp the tilting and focus hooks on the spotlight to focus and adjust the spotlight from the floor.

In the field of light control there is new equipment for television productions, which can be rolled from one studio to another. In the past year simplified circuits for dimming fluorescent lamps by adjustable reactors have been used for large and small installations. Last spring another non-electronic dimming system was announced, and is said to provide a wide range in brightness and excellent stability.

Each year the spotlights for highlighting objects become more and more refined. This year we have a recessed spotlight with a complete 60-degree adjustment without any part extending below the ceiling. One interesting feature is that when the unit is serviced from an attic the light beam can be aimed by a method other than trial and error, and a scale in the back of the unit is marked with degrees of tilt.

There have been important developments in the school lighting field. One manufacturer has introduced an interesting creation of the luminous ceiling which comes in packaged units. The units are adaptable to any room since the luminous elements do not extend to contact with the outer wall. When they are used in a room which is properly decorated, illumination levels of 50 footcandles with brightness characteristics conforming to recommendations of the American Standard Practice for School Lighting, are provided.

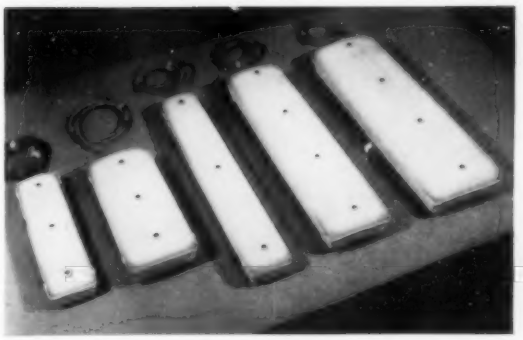


Figure 33. Family of simplified line of overhead fluorescent lighting luminaires for shipboard lighting.

Much attention has been given to the natural daylighting of schools. An important contribution has been a neutral, low-transmission, clear glass which screens out excessive brightness and glare, but gives clear vision from within with no alteration in the natural colors of the objects seen. Designers are using areas of this glass for minimum-glare, outdoor vision while adjoining areas of directional glass or glass block bring in the necessary light for seeing to all parts of the room. Another method of controlling daylight is a new plastic louver panel. The panel is used in vertical openings as a means of providing the desired cut-off angle for sun and sky glare. These designs make it possible to stay within the same brightness limitations for daylight as for electric light sources.

A simplified line of fluorescent overhead lighting luminaires was developed for Navy shipboard use. These luminaires represent a method for obtaining a variety of designs, from 16 watts to 60 watts, by using a few basic unit housings with interchangeable components. Fifteen luminaire types are obtained from five basic designs and this simplified line has permitted a reduction in the total number of overhead luminaire designs by nearly 50 per cent.

In the street lighting field a new refractor was developed for use on residential streets. This unit was designed to meet the American Standard Practice for Street and Highway Lighting and has open type glass construction which makes relamping easy and provides excellent cooling for larger lamps. It

Figure 34. Open type refractor for residential street lighting.

Figure 35. Small 100-watt mercury street lighting luminaire for use on secondary streets.

Figure 36. Disconnecting socket in mercury street lighting luminaire.

Figure 37. Streamlined adjustable gasoline station pump island luminaire.

Figure 38. Outdoor mercury floodlight for 400-watt, 700-watt, and 1000-watt mercury lamps.

will accommodate a 100-watt or 175-watt mercury vapor lamp and is also designed for incandescent lamps. A new open-type reflector efficiently utilizes the 100-watt tubular bulb mercury lamps for lighting secondary streets.

A new disconnecting socket was developed for mercury street lighting luminaires which provides safety at the high voltage involved.

Two new luminaires were developed for floodlighting. One is a new gasoline station pump island luminaire which tilts, utilizes a mercury lamp and has a ballast built integrally within the luminaire. The other is the first floodlight specifically designed to utilize a 400-watt and 1000-watt mercury lamp. This floodlight has a newly designed optical system with a fluted reflector which prevents re-direction of light through the mercury arc tube.

What's New in . . .

Lighting Applications

In most American factories production starts when the lights go on. Today the production rate per man hour is 150 per cent of the 1940 rate. This is partly due to better lighting which also results in less spoilage, fewer accidents, better products and more of them. In industry a few years ago 20- or 30-footcandles was thought to be high. Today the most ordinary type of industrial operation is often conducted under 50 or more footcandles, and in some instances the general lighting levels are up in the order of 200 footcandles. Today it is not unusual to find the factory lighted as well as the office.

One new modern Engine Research Laboratory building has been completely equipped with a modular, acoustic-baffled, luminous ceiling lighting system. The striking appearance of the well-lighted interior, plainly visible from the outside, shows that light can be both functional and decorative yet provide the maximum in advertising value while doing a utilitarian job. However, the most important feature of this building is its modular construction. In designing this building the 5-foot T-17 fluorescent lamp was chosen as the standard lamp, and its 5-foot dimension served as the basic module for the construction of the entire building. This concept of designing a building around the module of the light source is a step forward in the recognition of the importance of lighting in building design.

A large number of new office buildings have been completed during the past year. The trend seems to be, in most office building lighting, toward the use of recessed luminaires, recessed into acoustical material. It has been necessary, for the past few years, to have closer cooperation between ceiling manufacturers and luminaire manufacturers in order to simplify the installation of both the ceiling materials and the recessed lighting units.

A new and effective solution to the old problem of corridor lighting has been to combine an acoustical ceiling with a louver system to provide a good brightness of wall and ceiling together with an interesting architectural treatment. The acoustic corridor ceiling has been extended only part way across the corridor, with the remaining distance emitting light from a continuous row of rapid start fluorescent lamps concealed above the louver system spanning the remainder of the distance. While not required for adequate corridor lighting, incandescent downlights have been recessed at the elevator entrances to increase the level of the illumination in this high density traffic area.

Figure 39. Modular, acoustic-baffled, luminous ceiling lighting system in engine research laboratory building.

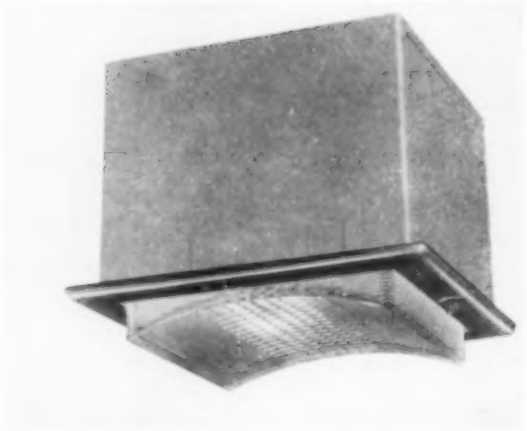


Figure 40. (Left) Combination corridor lighting utilizing acoustical ceiling and louver system.

Figure 41. (Above, right) Recessed corridor lighting unit.

It is a well-known fact that crime and light do not mix, and banking establishments have made good use of that fact in providing adequate light and visibility for security. Of all the forms of building architecture, that of the modern bank has undergone the greatest changes, and lighting has played an important part in this architectural progress. One method of minimizing the distinction between indoor and outdoor areas has been to use a luminous ceiling lighting system, continuous from inner to outer areas, only changing the type of material to provide better properties to withstand the outdoor elements. High level lighting installations have also made "drive-in" banking by night a feasible operation.

Some of the lighting in one of Miami's newest hotels is custom built and strictly decorative in nature. In this type of lighting application, efficiency is of lesser importance since the object of the lighting is the decorative effect. New effects in

Figure 42. Luminous ceiling lighting system in a modern bank minimizes the distinction between indoor and outdoor areas.

the decorative use of light are constantly being worked out in the decorative field. One new idea, which can readily be adapted to many areas of novelty decorative lighting, is the use of perforated wall panel materials with adequate lighting behind them. The light spills around the edges and changes a rather uninspired building material into a beautifully textured surface for decorative purposes.

Among the unusual in lighting units is an all metal chandelier in the lobby of the Barbizon Plaza Hotel. This twelve-foot diameter chandelier weighs only 140 pounds. The overall design, inspired by time's oldest night light system, the Galaxy of Stars, is a complex maze of shiny-nickel tubes and brass rods and twinkling bulbs (192 of them) which revolves very slowly against the lobby ceiling. A transformer is mounted in the lobby ceiling and supplies 40-ampere, 6-volt current which is carried to the light bulbs through the bare nickel tubing and returns through the brass rods.

Enjoyment of the better things of life is always improved by good lighting, and in the Whitney Museum, a luminous ceiling covers the art gallery rooms. A feature of this installation is the use of parabolic specular reflectors to project light downward at 30 degrees to the vertical through slanted photolight louvers, which are integral with the glass panel. This combination produces a high level of illumination on the paintings, as well as maximum comfort for the viewers in the gallery.

School lighting continues one of the fastest growing fields in lighting. After years of effort the American Standard Practice has become the "bible," and few schoolmen now question the value of good illumination in teaching. Last year 60,000 new classrooms were built (and lighted), but according to the best available information the country is still short 300,000 classrooms. School enrollment continues to increase by 1½ million students per year and to remedy the shortage by 1960, school systems will need to build (and light) 120,000 new classrooms a year. The relighting of old classrooms has continued at a greatly increased pace, but to date only 25 per cent of the existing facilities have been relighted.

There have been important developments in the architectural design of classrooms. The use of ceilings as low as 9 feet has been approved in New York and Connecticut, and schools have been built with this ceiling height in a number of other states. This method of construction will affect future lighting equipment design and will call for increased dependence on electric illumination. There are several widely used new approaches to this problem and much special study is being devoted to it. Whether or not daylight is used, an adequate electric system is required and is being installed.

The use of various types of sky lighting or "top" lighting has been given much study. Several exterior louver designs have been developed in connection with "top" lighting which are designed to exclude direct sunlight from the classroom, thus effecting thermal control and comfort as well as daylight control.

However, the most dramatic portrayal of the progress in American educational facilities is a travelling exhibition known as "Schoolroom Progress U.S.A." It depicts graphically the contrast of the American schoolroom of the past, as illustrated

Figure 43. High level illumination makes "drive-in" night time banking a practical operation.

Figure 44. (Above) Decorative lighting in Japanese theatre lobby.

Figure 45. (Above) Decorative lobby lighting with lighting units set in domes. General lighting is from recessed units, and cold cathode cove lighting.

Figure 46. (At left) Unusual and decorative all-metal chandelier in hotel lobby.

by the McGuffy Reader Car, with the schoolroom of today. This demonstration railroad car is sponsored by the Henry Ford Museum and others, including five manufacturers of lighting equipment. It will visit 40 major cities per year for two or more years, and will do much to spread the story of good lighting.

Stores begin to sell when the lights go on. Competition for the buyer's attention, and efforts to speed and simplify shopping by means of better lighting, places the lighting of American stores at a new high level. Today, chain stores are commonly lighted to an average level of 75 footcandles and some of the newer ones are going in with 150 footcandles and higher, with the emphasis on vertical surface lighting. Stores are lighted brightly so that they seem bright even in daylight because today if a store is unlighted or even dimly lighted people think it is closed. New interest is shown in external decorative and eye catching light, sometimes on the trees, flowers and plants and lawns as well as the building.

Vertical luminous areas or sloping wall panels near the ceiling have been used to good advantage to provide added light for selling or other purposes. These introduce new problems in computing lighting levels and in providing seeing comfort, but offer a wide field for development.

Sports lighting, particularly the spectacular lighting for night baseball has revolutionized this form of spectator entertainment. It has also made possible and practical, participation in sports in all seasons both indoors and outdoors. A new recreational layout in Burbank, California is thought to be the first such field completely illuminately solely with color-corrected mercury vapor floodlights. This system of lighting seems especially applicable to the recreational field where long hours of operation and low power costs are important.

The maintenance of overhead lighting systems for swimming pools has long been a problem. One solution is a new installation of a luminous ceiling which is serviced from above.

Patterns produced by the lighting equipment have been noted from time to time, in the past. Usually in the design of a pattern for a lighting

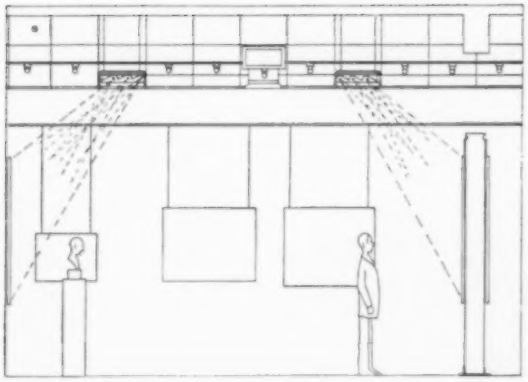


Figure 47. Cross section of art gallery showing luminous ceiling installation which produces high level of illumination on the paintings and creates a comfortable viewing atmosphere for the observers.

Figure 48. "Top" lighting for classroom which effects thermal control and comfort as well as daylight control.

installation, the engineer or architect has been concerned primarily with the functional aspects, and secondly with the appearance of the pattern. A definite trend appears now in the selection of patterns created by the lighting luminaires towards a reversal of this emphasis. There is a growing number of patterns predicated primarily upon the visual appearance of the pattern and secondarily upon the lighting levels and lighting uniformity which results. Wide variations are noted in use of exposed luminaires, troffers and downlights as developed here in America and elsewhere throughout the world.

Modern lighting on the farm is partly responsible for the fact that, today, one man can operate a 123-acre farm, whereas only ten years ago 1⅓ men were required to operate the same acreage. City folk seldom appreciate the extent to which American farms are now electrified and electric lighted. Lighting for production on the farm is a specific problem by itself, and of the 5,100,000 farms 4,800,000 are electrified and use electric light. One new development in farm lighting, within the past year, is the harvesting of vegetables at night to obtain greater market value. Another new development is the use of the new 250-watt R-40 brooder lamp. This lamp provides a wider and more uniform beam, thereby permitting separation of the piglets and helping prevent the mother sow from rolling on them. With poultry and young chicks it prevents crowding and "piling up." Inspection lighting now includes automatic color sorting machines, for produce such as eggs, beans, tomatoes and cherries, using several spectral bands of light and photoelectric cell. On the West Coast light is

Figure 49. Lecture room display demonstration using ultra-violet light and fluorescent chalk enables students to view lantern slides while material is illustrated on chalkboard.

being used to increase the fish population — a new role for visible radiation.

Bactericidal lamps made penicillin possible, and modern medicine could not exist if the protective rays of these lamps were not used universally in pharmaceutical plants. The newest sources in this field are being used to destroy odors. One of the latest developments is a self contained package

Figure 50. (Left) Lighted shrubbery around restaurant provides beauty as well as eye catching effect.

Figure 51. (Above) Near vertical sloping wall panels provide luminous areas near the ceiling.

Figure 52. (Above) Mercury vapor lighted softball field in Burbank, California.

Figure 53. (Right) Luminous ceiling installation in swimming pool building is maintained from catwalks above installation.

which can readily be inserted in existing air ducts to rid the air of germs and deodorize at the same time. An increasing interest is being shown in the use of ultraviolet for water purification. Its use is intended for private water systems and where chlorine-free water is needed.

In modern life, such a large part of which is "on wheels," the contributions of light to our safety and security are taken for granted. Our streets are lighted; traffic signals organize a flow of vehicles and people through our streets. Insurance people, who have a special interest in our well-being, are enthusiastic supporters of good lighting, and street lighting is one of their principal enthusiasms. The past year has seen a tremendous interest in all kinds of street and other outdoor lighting. Mercury still leads by a wide margin, with over 2000 miles of mercury street lighting installed in the past twelve months in the United States. Considerable and increasing interest is being shown in fluorescent street lighting, with over 50 miles of it installed in the United States. European interest is also great both in fluorescent and mercury street lighting. One city in Canada preserved the quaint old ball globe units for atmosphere but added mercury units for visibility.

A fascinating new lighting world that is found to have far reaching effects on American life includes hotels, shopping centers, gasoline stations and airports (these now include hotels, shops and

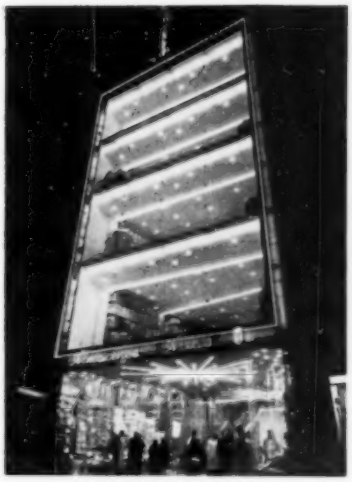


Figure 54. Patterns created by the lighting units

Left — Store in Madrid, Spain.

Center — Utility company lobby, Toronto.

Right — Bank lobby, Syracuse, N. Y.

Figure 55. (Above) Series of pools and dams comprising the "fish-ladder" at Bonneville Dam built to permit spawning salmon to get up the river.

Figure 56. (Above) Splash proof 1000-watt mercury lamps will illuminate experimental fish ladder to high levels to keep urging fish up the river to spawning grounds.

Figure 57. (Below, left) Self-contained, ready-to-plug-in bactericidal and odor-destroying lamp kit for installation in air duct of home heating system.

Figure 58. (Below, right) Street in Victoria, British Columbia after high mounted modern mercury units were added for visibility.

Figure 59. (Above) Competing outdoor auto sales areas combine to install effective lighting for automobiles on display.

Figure 60. (Right) Cleveland, Ohio rapid transit subway station.

Figure 61. (Above) Osaka, Japan subway station.

Figure 62. (Right) Mercury arc searchlight used as airway guiding beacon near airport. Planes at full throttle are guided over less populated areas to minimize noise complaints.

Figure 63. Railing and post light, used as a structural part of railings or fences, provides a means of lighting steps, walks, patios, etc.

Figure 64. Illuminated house number for permanent connection to the lighting system. The numerals are visible from both sides and can be read from a distance of 60 feet.

amusement centers). Outdoor applications of special interest include outdoor auto sales areas, new airway guiding beacons, subterranean streets and parking areas, subway stations.

All forms of travel today depend upon electric lighting. Nowhere is this more evident than in the automobile in which more and more lamps are being used. The average 1955 car has 22.8 electric lamps installed at the factory, more lamps than in the average home. Some cars have as many as 32 lamps installed at the factory and many lighted accessories may be added by the owner. One new accessory is a 12-volt trouble light which plugs into the cigarette lighter on the dashboard of cars with 12-volt systems.

New and interesting ways to solve a lighting problem are being worked out by lighting engineers in other parts of the world. In the decorative field the contributions from abroad are particularly noteworthy and inspiring.

Some comments on American lighting by visitors to the International Conference of the Electro Technical Commission in Philadelphia last year should be noted. They considered our generally higher lighting levels and our high degree of standardization in lamps and voltage frequency as particularly significant. They were also impressed with the widespread use of mercury lamps in street lighting and the rapid development of the luminous ceiling. Europeans report that their new installations also feature fluorescent lamps and mercury in street lighting today.

Lighting Education

Lighting has profited greatly this year because of a good job done in the field of education. Few industries have agencies comparable with the Better Light Better Sight Bureau, the Chicago Lighting Institute, and others.

Certified Lighting Bureaus have already been established in ten cities, with more planned. These Bureaus provide training courses, for lighting contractors, in good lighting design and in selling. They also certify lighting plans which meet industry standards.

Progress in . . .

Home Lighting

Lighting is fast becoming a primary instead of a secondary consideration on the part of the home maker. The beauty of the furnishings is lost without lighting, the comfort of the easy chair is nothing if adequate light for reading is lacking. The home is made up of many activities requiring light and to the American public this is fast getting to be their own point of view as evidenced by the growth of this, our largest market, in the past year.

Figure 65. Plastic bubble units lined up under the eaves lend a festive feel to the patio scene. The vertical panel at the right is a luminous screen which, when illuminated by colored light sources, may create whatever color effect is desired. A recreation room may be extended out into a patio area by use of full length glass so that in fair weather the room need not be limited by its architectural wall. Light and the use of glass extend it into a practically unlimited recreational area.

Figure 66.

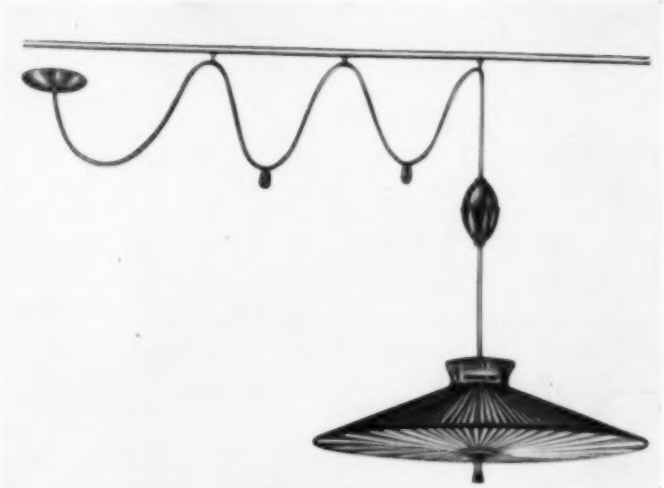


Figure 67.

Figure 66. Multiple lamp adjustable pendent unit, created by a series of graceful brandy snifters made of sparkling glass and polished brass. The snifters can be set at different levels by adjusting the length of the cords, and the diameter of the unit can be adjusted by sliding the slender horizontal brass bars through the vertical stem.

Figure 67. Counter-weighted pendent unit. The suspension and counter balance device for this unit moves across the ceiling on a brass track providing illumination at any point along a distance of 72 inches. The unit is also adjustable to three levels of illumination by use of the black knob which also serves as a handle for raising and lowering the unit.

Figure 68, above.

Figure 69, below.

Figure 68. Organ light specially designed for the illumination of the music and the keyboard of any piano or organ. It is constructed so that the light can be thrown out either top or bottom of the unit, or both as desired.

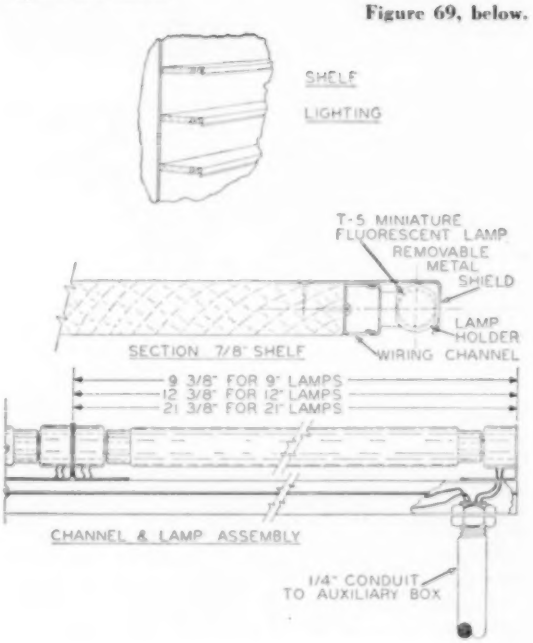


Figure 69. Construction details for lighting of small shelves. This demonstrates how standard light sources can be incorporated into a very thin shelf without making the shelf look equipment heavy. The auxiliary equipment is remotely located.

Figure 70. This dining room is illuminated with a fluorescent valance on one wall balanced by a luminaire unit built into the top of the breakfront. Both are on dimmers and color temperature of lighting can approach that of candles on the table.

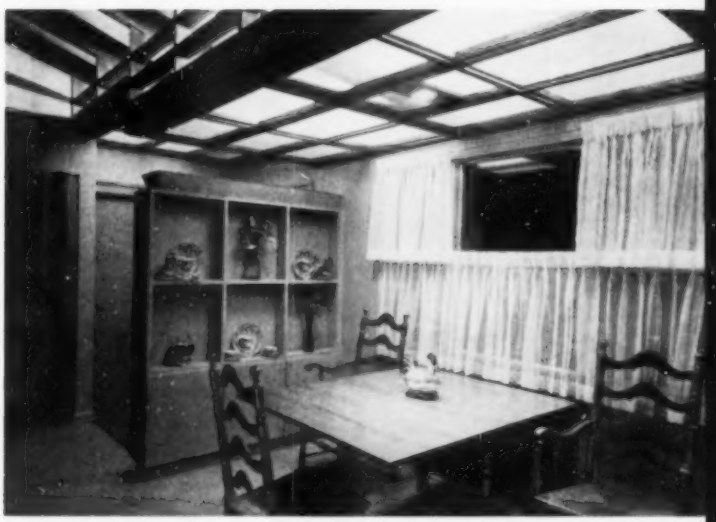


Figure 71. One of the prevalent techniques of applying louver ceilings to the home is that of breaking up its continuous expanse by the use of beams that may be either artificial or real, and may actually support the luminous ceiling as a working part of the construction. This room is a demonstration of this technique with much natural wood exposed to the viewer. Deluxe warm fluorescent lamps are used with an incandescent downlight over the dining table.

Figure 72. The solid hand hewn beams are a working part of the ceiling construction and support the corrugated luminous panels. The ceiling is approximately 12 inches below the under side of the roof and deluxe warm white lamps are used to give the warmest possible color.

Figure 73. This bathroom, with tile floors and walls (one a large mirror wall), is illuminated by an all luminous ceiling using deluxe warm white lamps on 12-inch centers concealed by corrugated diffusing plastic extending over the entire area including the shower. Bracket lights, shielded by frosted glass panels and angled at 45 degrees, combine with the overhead illumination for glare-free viewing of the face and head. Adjustable units, equipped with sunlight lamps, are mounted on the wall above the mirror. Two 75-watt R-30 lamps are mounted beneath the dressing table make-up counter to serve as pedicure lights, making foot care easier. A shielded ozone lamp and 7-watt night light are located under the towel cabinet behind the wood shield.

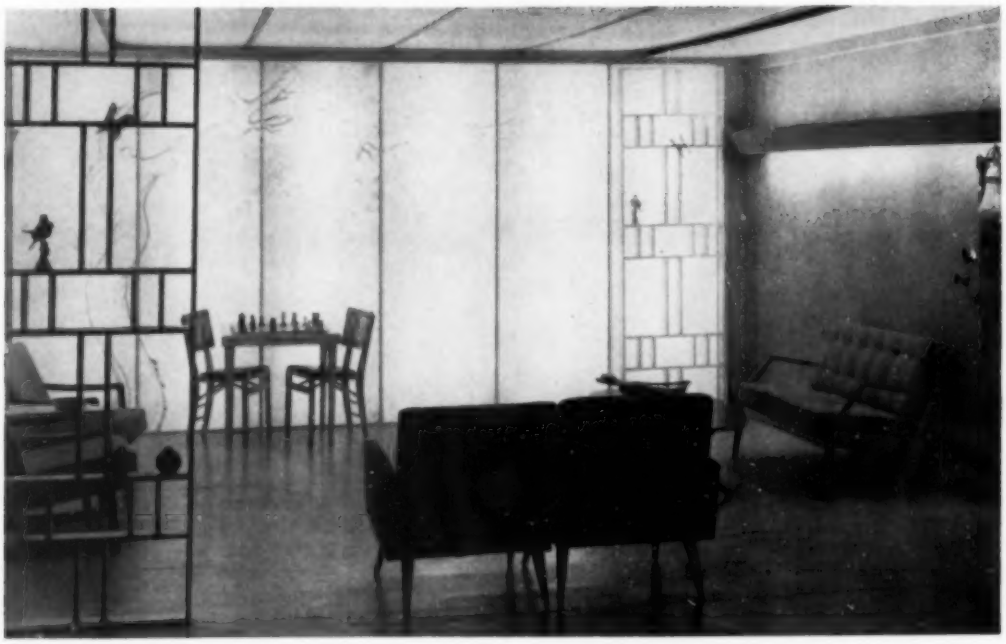


Figure 74. This laboratory room, with its dimmer-controlled luminous walls and ceilings, provides a means for studying and determining the preferred brightnesses or brightness limits of rooms for the home. Surfaces are at or near 50 per cent reflection factor.

50th Anniversary Issue

Several thousand extra copies of the special January issue of ILLUMINATING ENGINEERING, commemorating the Society's 50th Anniversary, were printed, and are available on order to the Publications Office, I.E.S. Headquarters.

On the Effect of Various Metal Electrodes On Brightness Waves in Electroluminescence

By PROFESSOR GEORGES DESTRIAU

Introduction

When an electroluminescent cell or condenser is subjected to a sinusoidal potential the light output flickers with twice the applied frequency. The "brightness waves" are defined as the curves showing the instantaneous light output of the cell as a function of time during one cycle of the applied alternating potential.

It was hoped to obtain possible improvement of electroluminescent cells by using a suitable metal backing. As a matter of fact, Piper and Williams,[1] using single crystals, pointed out a second emission peak occurring each half-cycle, the amplitude of which was dependent on the work-function of the metal electrode. However, Ueta[2] found no difference in the intensity of light output whatever the metal backing.

A direct comparison of the intensity of the light emitted by various electroluminescent condensers with different metal backings is only possible if the thicknesses are quite similar; but, because of the difficulties experienced in making such thin layers, it was thought that a study of brightness waves would be able to supply, more accurately, suitable information in order that either the brightness or the efficiency of electroluminescent cells could be improved.

General Behavior Of Brightness Waves

Brightness waves are characterized by:

(a) A phase shift of the brightness wave compared to the applied sinusoidal potential wave.

(b) A difference between the heights of the two successive primary peaks which occur each cycle near the time when, in each half-cycle, the potential is maximum.

(c) A small disturbance which can occur either before (on the left side) or after (on the right side of) the main peak, in point of view of time.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. AUTHOR: Laboratoire de Luminescence, Faculte des Sciences de l'Universite de Paris, France; Consultant: Westinghouse Electric Corp., Lamp Division, Bloomfield, N. J.

For the same phosphor, at room temperature, brightness wave forms are dependent on the following factors:

1. The frequency,
2. The applied voltage or, more accurately, the ratio between voltage and thickness (*i.e.*, the field strength),
3. The ratio between thickness of phosphor and thickness of insulator, if one is present,
4. The absolute thickness of the phosphor layer,
5. The metal backing.

The dependence of brightness waves on factors 1 and 2 has already been reported[3,4] and can be summarized as follows:

I. Phase shift of the brightness waves. A progressive shift ahead, when voltage is raised, ascribed to an increase of the small conductivity of electroluminescent crystals (the effective internal field being itself shifted ahead when the conductivity increases) and an opposite and progressive shift, when frequency is raised, ascribed to the mean life time of an excited center (10^{-4} to 10^{-3} second, according to the phosphor). The relative importance of the mean life time, compared to the period, becomes greater when the frequency is increased. At low frequency the brightness wave leads the potential wave, at about 2000 cps the brightness wave and potential wave are in phase, and at frequencies higher than 2000 cps the potential wave leads the brightness wave.

II. The secondary disturbance and asymmetrical peak heights. A progressive change in the disturbance which passes, when the potential is increased, from the right side to the left side while simultaneously the polarity of the highest peak passes from transparent electrode negative to transparent electrode positive. When the frequency is increased, a progressive weakening of the disturbance which vanishes progressively so that, at high frequency, the brightness wave assumes a more symmetrical form. New experiments have been made with various metal backing and the same behavior occurs whatever this metal backing (Fig. 1).

The dependence of brightness wave forms on fac-

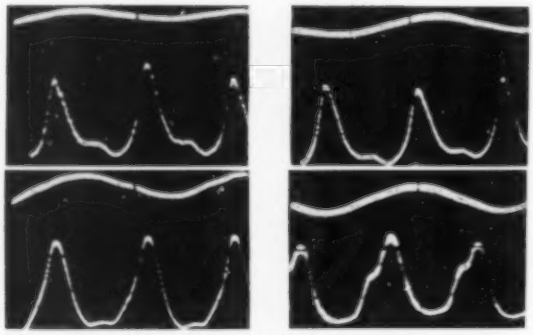


Figure 1. Brightness waveforms as a function of applied potential. (1) 160 volts, (2) 240 volts, (3) 400 volts, (4) 500 volts. In (1) and (2) the disturbance occurs after the main peak and the highest peak occurs when the transparent electrode is negative. In (4) the disturbance occurs before the main peak and the highest peak occurs when the transparent electrode is positive.

tors 3, 4 and 5 above has not yet been published. These questions will now be discussed.

Shift of Brightness Waves Relative to Potential Waves According to the Thickness of Electroluminescent Cells

In order to explain the phase shift of brightness waves it was shown many years ago[5] that, because of the low conductivity of electroluminescent crystals, the internal effective field in the crystals is out of phase with the external field (field in the insulator round the crystal). The internal field leads the external field by an angle ψ such that

$$\tan \psi = 2/K_1 \rho f,$$

where K_1 is the dielectric constant of the crystal, ρ is its specific resistance, and f is the frequency.

But, if the above formula is correct, it was wrong, on the other hand, to consider that the external field (in the insulator round the crystals) and the applied potential are in phase. For the rough model of two parallel layers, the thicknesses of which are, respectively, a for the phosphor layer and b for the insulating layer, it is easy to show that the applied potential itself leads the external field (field in the insulator) by an angle γ such that

$$\tan \gamma = \frac{2K_2 \rho f}{4^{b}/_{a} + K_1 \rho^2 f^2 (K_2 + K_1 {}^{b}/_{a})},$$

and the internal field (in the crystal) leads the applied potential only by an angle φ such that

$$\varphi = \psi - \gamma.$$

γ, and thus φ, is dependent on the ratio b/a.

If $b/a = 0$ (electrodes in contact with the crystal) the corresponding value γ_0 of the angle γ is

$$\tan \gamma_0 = 2/K_1 \rho f.$$

Thus $\gamma_0 = \psi$ and the corresponding angle φ is zero so that, in this case, the internal field and applied potential are in phase, as they obviously should be. If the ratio b/a is increased, γ decreases and for infinite b/a tends toward zero. Thus in this case, and only in this case, the internal field leads the applied potential by the angle ψ.

In order to check such predictions, different cells have been made. The thicknesses of these cells were 5, 10, 15, and 20 thousandths of a centimeter, while the thickness of the electroluminescent layer in each cell was always about 2.5×10^{-3} centimeter. Thus assuming that at low frequency (50 cps) the mean life time of an excited center (10^{-3} to 10^{-4} second) is short enough compared to the period of the field variation so that the brightness wave and the internal field are in phase, the values of φ can be directly measured by the shift of the

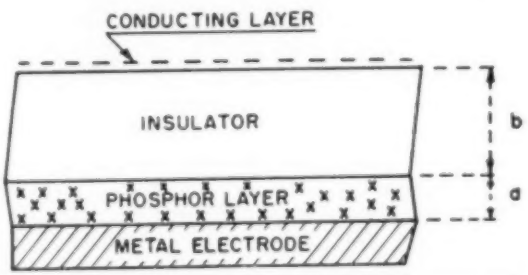


Figure 2. Cross-section of an electroluminescent cell. (a) Thickness of the phosphor layer (2.5×10^{-3} cm). (b) Thickness of insulator. The total thickness (a + b) is, according to the cell used, 5, 10, 15, or 20 thousandths of a centimeter.

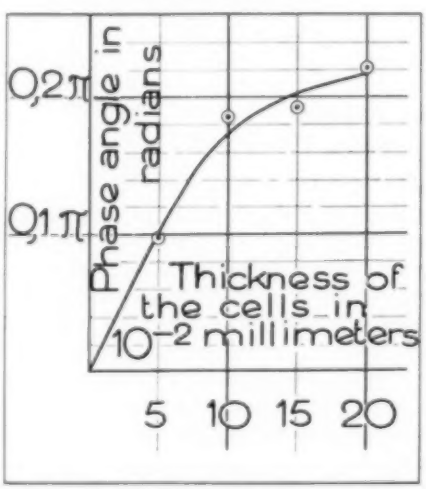


Figure 3. Variation of the phase angle φ as a function of the thickness of the cell. The solid curve is the theoretical curve.

brightness waves compared to the sinusoidal potential waves.

Then:

$$\tan \varphi = \tan (\psi - \gamma) = \frac{2}{K_1 \rho f (1 + (K_2/K_1)(a/b))},$$

$$\tan \varphi = \frac{\tan \psi}{1 + k x},$$

with $k = K_2/K_1$ and $x = a/b$.

Fig. 3 shows the theoretical curve with $\tan \psi = 1.065$ and $k = 2.2$. The experimental points are plotted upon this curve, which fits conveniently the experimental results.

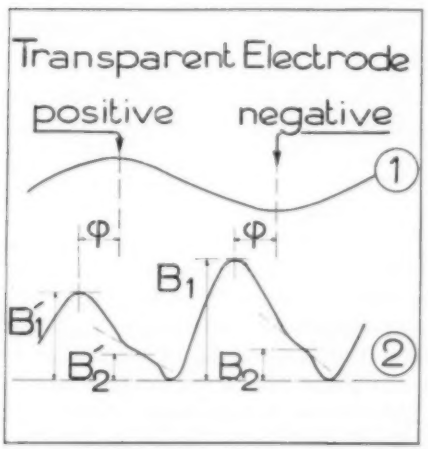


Figure 4. The principal characteristics of a brightness wave. (1) Sinusoidal potential wave, (2) brightness wave.

Dependence of Brightness Wave Forms on Absolute Thickness of the Phosphor Layer

Usually with symmetrical cells (*i.e.*, two identical electrodes) and phosphor embedded in an insulator between conducting glass or mica, and with phosphor layers not too thick, the brightness waves have a regular form with only a small difference between the heights of the two successive peaks in each cycle of potential variation.[6] Thus, the secondary disturbance occurs only when one layer of the electrodes is a metal in contact with the phosphor layer or separated from it by a very thin insulating layer, and this disturbance is more or less marked according to the metal electrode, as we shall see below.

However, closer study shows that, even with symmetrical cells without any crystal-metal contact, the disturbance appears when the phosphor layer thickness is higher than a certain value so that many crystallites are superimposed in the field direction. Furthermore, with some products, especially some zinc sulfides oxidized on the surface, the disturbance always occurs in symmetrical cells whatever the thickness of the phosphor layer.

Dependence of Brightness Wave Forms On Metal Backing

In order to avoid all sources of error arising from the various factors discussed above, comparison between different metal backings requires cells of a constant thickness in which the same thickness of phosphor is subjected always to the same potential and the same frequency. For this purpose, cells were made of a suitable phosphor layer fixed upon a mica sheet by a very thin solid insulating layer; another thin but conducting layer is then deposited upon the opposite face of the mica and the various metal sheet electrodes are successively placed in contact with the phosphor and pressed against the sensitive layer. In each experiment a thin layer of oil avoids all air bubbles. The total thickness of sensitive layer and mica is very great compared to the oil film so that, using always the same mica and the same phosphor layer deposited on it, the total thickness is conveniently constant whatever the metal backing. Experiments have been made with a frequency of 50 cps and with each metal many brightness wave recordings at many potentials were taken.

Let B_1 and B'_1 be the heights of the two successive chief peaks and B_2 and B'_2 be the heights of the secondary peaks, or the heights of the inflections which immediately follow the first ones (Fig. 4). The brightness waves can then be characterized by the following quantities:

(1) By the phase angle φ between potential wave and brightness wave.

(2) By the ratio

$$m = 2 \frac{(B_1 - B'_1)}{(B_1 + B'_1)}.$$

This ratio will be called the "modulation ratio."

(3) By the ratios

$$d = B_2/B_1 \quad \text{or} \quad d' = B'_2/B'_1.$$

These ratios will be called the "disturbance ratios." d and d' are usually nearly equal.

Metal electrodes can be characterized by the electronic work function, which is very dependent on the condition of the surface; the usual tables give only values for material in vacuo. On the other

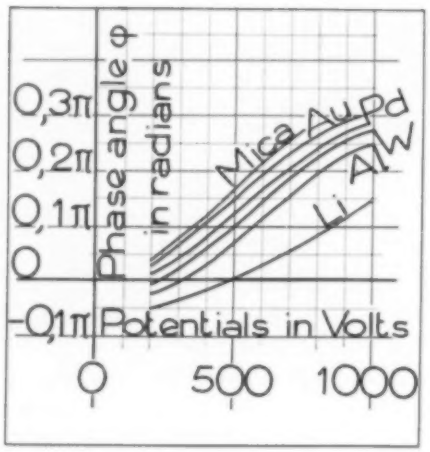


Figure 5. Variation of the phase angle φ as a function of the applied potential for different metal backings. Phosphor: ZnS(Cu), Green, Lehmann.

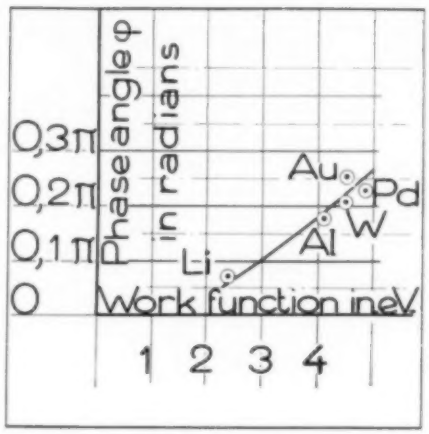


Figure 6. Variation of the phase angle (at a potential of 750 volts) with electronic work function of the metal electrode. Phosphor: ZnS(Cu), Green, Lehmann.

hand, the work functions of many metals are of the same order of magnitude. For these reasons three metals, the work functions of which are quite different, were used for the experiments.

Metal	Work Function (e.v.)
Palladium	4.9 — 4.98
Aluminum	4.0 — 4.25
Lithium	2.4

However, besides these three metals, gold, wolfram, lead, and silver were also tested. The same phosphor layer was also used with a sheet of mica placed between the metal and the phosphor layer, in this case, because of the poor electrical conductivity of mica, such cells can be considered as made with a metal backing of very high work function. However, in order to take into account the greater thickness of such symmetrical cells compared to cells in which the phosphor is directly in contact on one side with a metal, the applied potentials have been suitably adjusted in order to compare always results obtained with field strengths in the phosphor of the same order of magnitude.

The phase shift, φ, of the brightness waves compared to the potential wave is different according to the metal used, as shown in Fig. 5. With a copper-activated zinc sulfide giving a green emission and prepared by W. Lehmann, at low potentials and with metals of low work functions, some small negative values of φ were found. This effect was unexpected. As a matter of fact, the phase angle φ of this phosphor increases rapidly with the applied voltage; such an increase of φ has been reported previously with other phosphors, but up to the present, no phosphor giving such a marked variation had been found. If we cut the group of curves of Fig. 5 by a straight line V = Constant (for example, V = 750 volts) we obtain the curves of Fig. 6 which give φ, for this potential, as a function of the metal electrode.

With regard to the "modulation ratio" and to the "disturbance ratio," the results are quite different according to the phosphor used. With the Lehmann sample mentioned above, the disturbance ratio decreases when the voltage is raised but we obtain similar variations whatever the metal backing. One can see, however, a small difference in the form of the disturbance, which is an inflection with lithium and a true secondary maximum with palladium or mica (see Fig. 7). The "modulation

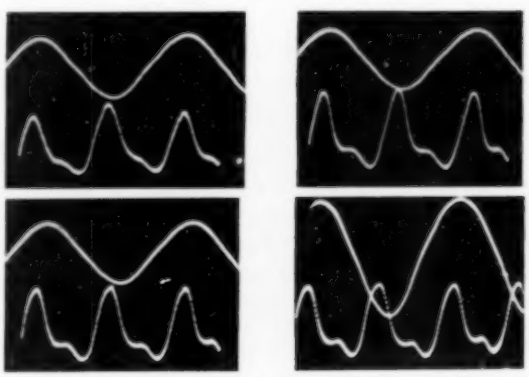


Figure 7. Brightness waves for the same field strength. Phosphor: ZnS(Cu), Green, Lehmann. (1) Lithium, (2) aluminum, (3) palladium, (4) mica. Note the different shift of the brightness waves compared to the sinusoidal potential waves, and the disturbance which progressively passes from an inflection in (1) with lithium to a small secondary peak in (3) and (4) with palladium and mica.

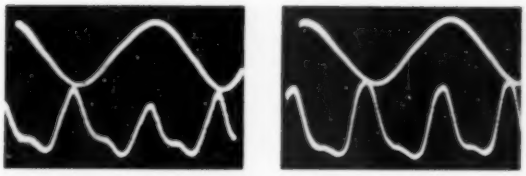


Figure 8. Brightness waves for the same field strength. Phosphor: ZnS(Cu), blue. (1) Lithium, (2) palladium. Note the smaller phase shift in (1) than in (2) and the difference in the modulation ratio as well as in the disturbance ratio.

ratio" is always small and detectable differences between the various metal backings are not observed.

With another phosphor prepared in our laboratory (another copper-activated zinc sulfide, but emitting in the blue rather than in the green) we obtain, with the same field strength, the values given in the following table.

Electrode	Disturbance Ratio
Mica	0.06
Palladium	0.09
Aluminum	0.17
Lithium	0.24

The "modulation ratio" for the same phosphor in the same conditions is about 0.09 for mica, palladium, and aluminum but is 0.30 for lithium so that, for this phosphor, considering simultaneously the "disturbance ratio" and the "modulation ratio," one can say that the brightness wave disturbances are greater with metals of low work function than with metals of high work function (see Fig. 8).

Conclusions

The above results show a noticeable dependence of emission upon the work function of the metal electrode. At the present time it is still too early to make use of these results in order to improve the light output from an electroluminescent condenser but it is believed that, in the near future, an improvement might be obtained by an equal division of the light emission during the two successive half-cycles of the sinusoidal potential variation. Such an equipartition in the light emission could be precisely obtained by a suitable metal backing adapted to the phosphor as well as to the potential usually applied to the electroluminescent cell.

Acknowledgements

The author is indebted to Mr. W. Lehmann of the Research Department, Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey, for supplying the phosphor sample mentioned and to Dr. H. F. Ivey, of the same laboratory, for aid in preparing the English text of this paper and discussion on the matter.

Bibliography

1. Piper, W., and Williams, F. E.: *Phys. Rev.*, Vol. 87, 151 (1952).
2. Ueta, M.: *J. Phys. Soc. Japan*, Vol. 8, 429 (1953).
3. Destriau, G., and Mattler, J.: *J. Phys. Radium*, Vol. 6, 227 (1945); *Comptes Rendus*, Vol. 220, 913 (1945).
4. Destriau, G.: *Brit. J. Appl. Phys., Suppl. No. 4*, 49 (1955).
5. Destriau, G.: *J. Chim. Phys*, Vol. 34, 462 (1937).
6. Zalm, P., Klasens, H. A., and Diemer, G.: *Philips Res. Rep.*, Vol. 9, 81 (1954).

DISCUSSION

F. F. Morehead:* Professor Destriau refers to the phenomenon of asymmetrical peak heights in which the higher peak at low voltages becomes the lower peak at high voltages. This effect can be shown to occur when one electrode can make electrical contact with some of the phosphor particles while the other electrode is insulated from such contact. Consider a cell in which one electrode, either the conducting glass or the metal electrode, is separated from the binderless phosphor layer by a thin insulating layer. At low voltages the higher peak (by a ratio of as much as 10:1) occurs when the contacting electrode is becoming positive while at high voltages the higher peak (by up to 5:1 before breakdown) occurs when the contacting electrode is becoming negative. This behavior is in accord with Professor Destriau's observations. A possible explanation is that the field in the exhaustion barrier region where the electroluminescent processes are believed to occur[1] is drastically decreased if electrons removed by the field from the exhausted region are unable to leave the phosphor particle. Hence in the cell described above a higher field occurs in the barrier region when the non-contacting electrode is negative since electrons can then escape the particle into the contacting electrode. This escape cannot occur when the contacting electrode is negative during the other half-cycle, hence the higher field and hence the higher light output at low voltages occurs when the contacting electrode is positive. At high voltages electrons may enter the barrier region from the contacting electrode when it is negative and contribute to the process of light production so that the higher peak occurs at this time. In this latter effect a dependence on the work function of the metal might be expected.

1. Piper and Williams, *Phys. Rev.*, 87, 151 (1952).

Arrigo Addamiano:** I understand that the phosphors used by Professor Destriau in his research were some activated zinc-sulphides. I wonder what the concentration of impurities was and whether Professor Destriau has investigated the effect of a systematic change of the concentration of impurities on the shape and phase of the brightness waves.

John F. Waymouth:† Professor Destriau's description of his work leaves several questions in my mind. The first has to do with his assumption that the phase angle of the maximum of the brightness wave and the phase angle of the maximum of the internal field are the same. It seems unlikely to me that this assumption could be correct over any

*Advanced Lamp Development Laboratory, General Electric Co., Nela Park, Cleveland, Ohio.
**General Electric Co., Nela Park, Cleveland, Ohio.
†Engineering Laboratories, Sylvania Electric Products, Inc., Salem, Mass.

extended range of field strengths. It amounts to assuming that only *excitation* of luminescent centers takes place in the high field (presumably by impact of electrons accelerated by the field). Our experiments[1] indicate that electrons are actually removed from luminescent centers by the field, and cannot recombine with the emission of radiation until the field is removed. If this process predominates, the maximum of light emission should coincide with the zero of internal field rather than its maximum.

Another question is, what is the effect of the various metal electrodes on the absolute brightness of the electroluminescent cells? His very ingenious technique for the construction of experimental cells using the same phosphor sample with different metal electrodes overcomes very acceptably the objection that variations in thickness of the phosphor layer mask effects due to the electrodes.

In contradiction to the conclusion reached by Professor Destriau, it is our opinion that significant improvement in the light output from electroluminescent cells cannot be obtained merely by making the light output each half cycle the same.

1. Waymouth and Bitter, *Phys. Rev.*, Vol. 95, 941 (1954).

GEORGES DESTRIAU:* Mr. Morehead expects that the behavior observed in the polarity change of the highest peak, when the voltage is increased, could be explained by the fact that, at high voltage only, electrons could escape from the metal backing and enter the barrier region. I agree that such a possibility is not excluded.

In reply to Mr. Addamiano's question, I emphasize that I have not investigated the effect of a systematic change in the concentration of impurities. The samples tested did not form a series where the activator contents were increased regularly, step by step, from one to the other. These phosphors were merly chosen among some of the best E. L. samples easily available to us.

I agree with Dr. Waymouth that, in each half cycle, a certain shift can occur between the maximum of the light emission and the maximum of the internal field. In our experiments, however, a constant frequency of 50 cps was always used and only results obtained for the same values of the potential were compared. Under these conditions, such a possible shift could merely modify all phase angles observed by the addition of a constant angle, and comparisons described above remain valid.

I have not compared absolute brightnesses because, even with our technique, some small variations between the different thicknesses can occur and absolute brightnesses are very sensitive to these variations, whilst noticeable changes in the brightness wave-forms require great changes in the field strength.

I am myself convinced that improvement of electroluminescent cells requires many other conditions in addition to making the light output each half cycle the same. It is still my own opinion, however, that maximum efficiency requires equal partition of the light output over each half-cycle.

*Author.

I.E.S. Emblem

The official emblem of the Illuminating Engineering Society is available to members in 14-karat gold, lapel screw back buttons, in the miniature ½-inch size, at only $3.50 each including taxes. Background of emblem is blue for Members, red for Associate Members. Emblems may be ordered from the General Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

INSTALLATION AT NORTH EGGERT ROAD SCHOOL, EGGERTSVILLE, NEW YORK.

Lighting a Low Ceiling Classroom

LIGHTING OBJECTIVE: To provide recommended levels of good quality illumination by means of incandescent lighting in a classroom with a low ceiling.

GENERAL INFORMATION: The first grade classroom shown above measures 29 feet by 27 feet, ceiling height is 9 feet 3 inches. Surface characteristics are as follows:

ceiling, perforated acoustic tile	white	80% RF
walls, cinder block	green	55% RF
trim	natural wood	40% RF
dado, asphalt tile	mottled gray	25% RF
floor, asphalt tile	dark green*	10% RF*
chalkboard	black*	7% RF*
desk top	natural wood	50% RF
window shades	light tan	60% RF

*The dark floor and chalkboard do not meet the recommendations of the American Standard Practice for School Lighting.

(over)

A.I.A. File No. 31

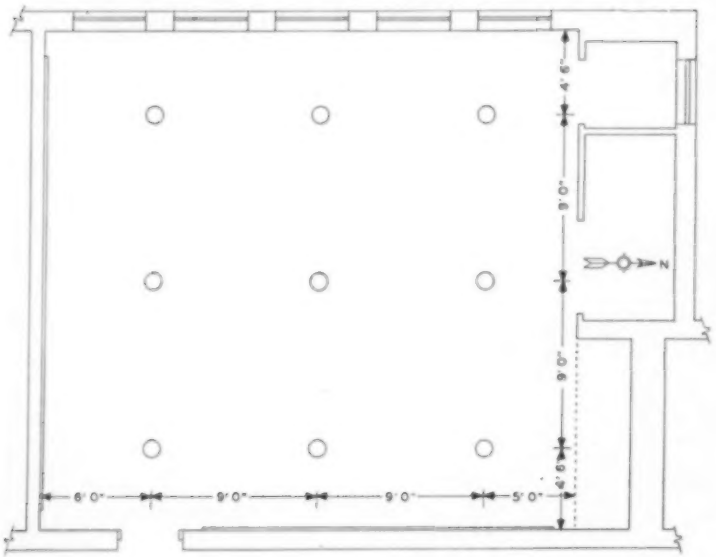


Figure 2. Plan view showing location of lighting equipment.

INSTALLATION: Nine pendent mounted concentric ring luminaires (Silvray Lighting, Inc. catalog No. 1500S/3R/5) using 500-watt PS-40 inside-frosted silvered-bowl lamps are suspended 24 inches overall and mounted 9 feet on centers as shown in Fig. 2. Average general illumination two months after installation, on a plane 23 inches above the floor (desk top height) measured 52 footcandles.

Brightnesses are as follows:

luminaire (at 45°) — Maximum	650 ft-L
ceiling	
maximum	130 ft-L
minimum	26 ft-L
front wall	
between rows of luminaires	12 ft-L
opposite row of luminaires	15 ft-L
trim	10 ft-L
dado	6 ft-L
floor	4 ft-L
chalkboard	2 ft-L
desk top	25 ft-L
window shades	15 ft-L

Lighting designed by E. S. Burrows, 259 Delaware Ave., Buffalo, N. Y.; architect: Duane Lyman and Associates, 505 Delaware Ave., Buffalo, N. Y.

Lighting data submitted by Niagara Mohawk Power Corporation, Buffalo, N. Y., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Series XXI 2-56

Effect of Bulb Wall Temperatures on Fluorescent Lamp Parameters

By CHARLES W. JEROME

This study was initiated as a result of findings encountered in the survey of fluorescent lamp parameters which was reported by Dr. Lowry last year.[1] In that study various sizes of lamps were operated over a large range of currents and their parameters, including bulb wall temperatures, measured. It was found that in most cases the lamps operated at maximum efficiency at much lower currents and bulb wall temperatures than had been expected.

This subject had been previously reported in the literature.[2,3,6] However, these investigators had confined their studies to the rated current for the lamps. With the present interest in high output fluorescent lamps attention has been focused on lamp currents considerably higher than previous ratings. Therefore, it was desirable to determine the effect of bulb wall temperatures at these new currents. It is possible that future developments may lead to lamp operation at still other currents. In an effort to anticipate this situation the present study was expanded to include the whole operating range of each lamp. With regular lamps, it was considered unsafe to exceed the rated current by more than a small factor since the cathodes are not designed to carry much of an overload. However, by presenting sufficient data over the safe range of currents, extrapolation can be made to higher currents with a fair degree of accuracy.

Experimental Procedure

Fig. 1 shows a schematic diagram of the apparatus used in this study. The lamp under investigation was operated inside an outer jacket through which water was pumped from a temperature controlled reservoir. A thermocouple cemented against the bulb at the center of the lamp was used to measure bulb wall temperature. The flow of water was great enough (approximately three gallons per minute) so that a differential of less than 0.1°C was maintained between the bulb wall and the temperature of the reservoir.

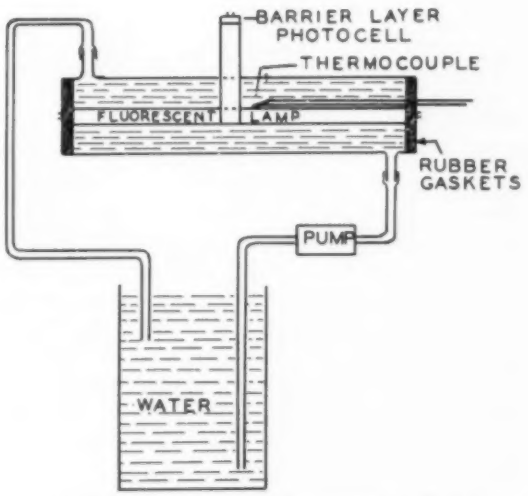


Figure 1. Water jacket for controlling bulb temperature.

The lamp was operated on a straight line reactor and the current changed by varying the reactor impedance keeping the supply voltage constant. Sufficient time was allowed at each new setting of current and/or temperature to insure that the lamp came to equilibrium.

Light output was measured through the water jacket by a shielded photocell. The factor for converting photocell output to lumens was determined by operating the lamp in air over the range of currents to be investigated and determining the lumen output by usual photometric means. At each reading, the bulb wall temperature was also measured. Then after completion of the operation of the lamp in the water jacket the photocell outputs at each current were plotted as a function of bulb wall temperature. Assuming that the light output in the water jacket at a given bulb wall temperature and current is the same as when the lamp is operated in air at that current and bulb wall temperature, factors can be determined for converting photocell output to lumens from the above curves. Such factors were determined for each current, and their average used for this conversion.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. Author: Sylvania Electric Products Inc., Salem, Mass.

Using this procedure the following cool white lamps were measured over the range of currents indicated and at bulb wall temperatures from 20°C to 50°C.

Size	Type	ma
15T8	Preheat	50-500
30T8	Preheat	50-500
15T12	Preheat	50-500
20T12	Preheat	50-500
40T12	Preheat	50-500
40T12	No heating of Fil. Rapid Start	50-500
96T12	Rapid Start	100-1500
40T17	Instant Start	100-600
90T17	Instant Start	200-1600

Results

It is seldom convenient to measure the bulb wall temperature of a fluorescent lamp in operation. However, it has been found that a simple relationship exists between ambient and bulb wall temperatures and this relationship is shown in Fig. 2. As would be expected, the difference between ambient and bulb wall temperatures depends on the diameter of the bulb, current and fill gas. As shown in the figure, a larger difference is found for smaller diameter tubes. Or, expressed another way, the small diameter lamps run hotter than large diameter lamps.

This relationship depends only on the bulb diameter of lamps filled to the same pressure with the same fill gas. For example, both the 15-watt and 30-watt T-8 lamps show the same bulb temperature at any current and the same holds true for the T-12 lamps. This relationship also depends on the type and/or pressure of fill gas used as evidenced by the different curve obtained for the 96T12 RS lamp. (1.5 mm, Argon-Krypton mixture) from that of the regular T-12 lamps (3.0 mm Argon) and the different curves for the 40T17 (Argon) and 90T17 (Argon-Krypton) lamps.

Another determining factor in this relationship is the speed of air movement past the lamp. In general, the faster the air movement, the smaller the difference will be between bulb and ambient temperatures due to the more rapid dissipation of heat from the bulb. Some data on this variant may be obtained from Figure 8-38, *I.E.S. Lighting Handbook* (p. 8-48, Second Edition, 1952).

The data in Fig. 2 were taken in still air with the lamps unconfined. With it the bulb temperature of a lamp operating in still air can be determined. For example, in an ambient temperature of 26°C, a T-8 lamp operating at 500 milliamperes will have a bulb temperature of 56°C (26 + 30) while a T-12 lamp at the same current will have a bulb at 45.3°C.

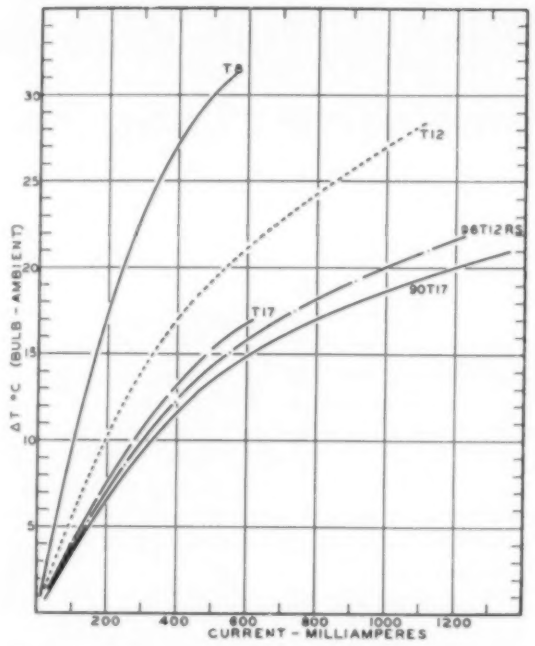


Figure 2. Difference in bulb wall and ambient temperatures at various currents in still air. Lamps filled with 3 mm Argon, except 96T12 RS (1.5 mm, 50 Argon: 50 Krypton) and 90T17 (2 mm Krypton). Bulb temperatures measured at center of lamp on bottom.

These experiments have led to the amassing of a very large number of data: nine lamps, operated at seven temperatures and eight currents and four parameters of each measured. These data present quite a problem in presentation. There are too many to list individually and doing so would only be confusing. For example, Fig. 3 shows the data for a 40T12 lamp at five different currents. The similarity of data on differentials between bulb and ambient temperatures of lamps of same diameter bulbs and fill gases suggested that this same similarity might exist for the electrical and luminous parameters. Of course, lamps of different lengths even though of the same bulb diameter have entirely different electrical parameters and light output. Therefore, the absolute magnitude of these values showed no similarity. However, it was found that expressing the parameters of any lamp at a constant current as percentages of the maximum at that current, led to results in which the variation in values of the same class (*e.g.* T-12 lamps) amounted to only one or two per cent. Therefore, the data listed and presented herein are in this form.

Tables I, II, III, IV and V list the average results of variation with temperature of lamp volts, lamp watts, lumens and luminous efficiency (*lpw*) ex-

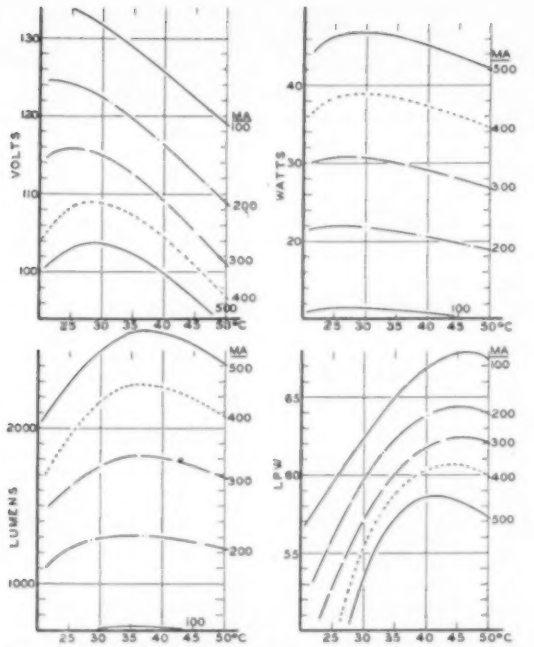


Figure 3. Effect of bulb wall temperature on electrical and luminous parameters of a 40T12 fluorescent lamp.

pressed as per cents of the maximum, at constant currents for all T-8 (2), T-12 (1) and T-17 (1) lamps filled with argon and 96T12 Rapid Start (Argon:Krypton) and 90T17 Argon:Krypton) respectively. These results are shown graphically in Figs. 4 to 8 inclusive. Also, in order that these results may be tied back to absolute values, Table VI lists the maximum parameters for each lamp at each current. In regard to Table VI it should be pointed out that these values are not necessarily representative of production lamps. Well aged lamps were used, some with as high as 4000 hours, and some of the lamps were specially made and trolley pumped expressly for this study. Also, since lamps of various burning times were used no consistent relation with rated values should be expected.

Discussion of Results

The results obtained in this study compared to those obtained by Holden[5] are tabulated in Table VII and are shown for the 40T12 preheat lamp in Fig. 9. This comparison shows fairly good agreement between the two sets of data over the range of temperatures included in this study. However, there seems to be a progressive deviation between the two sets towards the ends of this range. This may be due to the differences in the other lamp parameters effected by temperature in the data

TABLE I — Effect of Bulb Temperature on Parameters of T8 Lamps.

(Figures are Per Cent of Maximum at Each Current)

Temp.	Volts	Watts	Lumens	lpw	Temp.	Volts	Watts	Lumens	lpw
I. At 500 ma					V. At 250 ma				
13.6	89.6	85.5	31.6	36.6	13.6	92.5	87.4	36.3	41.4
20.1	91.2	91.0	50.5	55.0	20.1	95.0	92.0	56.3	61.1
25.5	98.0	96.6	71.8	73.6	25.5	99.1	97.2	79.4	80.5
30.5	100.	99.4	87.3	87.0	30.5	99.9	96.3	94.0	94.4
35.2	99.6	100.	95.4	94.5	35.2	100.	97.8	98.4	97.4
40.0	99.0	99.4	99.5	99.3	40.0	98.9	99.8	98.2	97.1
44.8	97.3	98.1	99.2	100.	44.8	95.6	97.0	96.9	98.5
49.9	94.2	95.0	94.0	98.0	49.9	91.1	93.0	92.1	97.9
II. At 400 ma					VI. At 200 ma				
13.6	89.8	85.3	33.0	38.7	13.6	93.5	87.8	35.2	40.1
20.1	93.5	90.8	52.4	57.6	20.1	95.1	92.3	54.0	58.6
25.5	98.4	97.0	74.9	77.2	25.5	99.8	97.5	79.0	79.1
30.5	99.6	99.5	88.9	89.3	30.5	99.6	98.6	88.6	87.9
35.2	100.0	99.0	95.7	96.6	35.2	99.8	100.0	99.2	96.9
40.0	99.0	100.0	100.0	100.0	40.0	98.0	98.6	94.6	93.6
44.8	98.2	99.2	98.8	99.7	44.8	94.3	94.5	91.9	94.9
49.9	94.7	95.0	93.5	98.8	4.9	91.0	92.1	89.0	94.4
III. At 350 ma					VII. At 150 ma				
13.6	90.9	94.5	34.1	39.7	13.6	4.8	90.0	39.8	44.3
20.1	94.5	90.5	54.0	58.9	20.1	95.6	93.2	58.6	62.8
25.5	98.7	95.3	75.3	78.3	25.5	100.0	99.0	84.5	83.9
30.5	100.0	98.2	89.8	90.5	30.5	99.1	100.0	95.3	93.8
35.2	99.7	97.9	97.5	98.5	35.2	98.4	99.3	98.2	97.4
40.0	98.8	99.1	100.0	99.9	40.0	96.4	99.7	97.0	95.8
44.8	98.2	98.3	98.6	98.8	44.8	93.2	94.9	94.2	97.7
49.9	94.1	94.1	93.8	98.6	49.9	90.4	92.6	93.8	99.6
IV. At 300 ma					VIII. At 100 ma				
13.6	91.3	85.3	35.5	40.8	13.6	96.5	93.0	46.4	46.8
20.1	94.0	90.7	56.3	61.1	20.1	95.8	94.2	64.3	63.9
25.5	98.8	95.0	77.6	79.8	25.5	100.0	98.7	86.5	83.1
30.5	100.0	96.4	90.9	92.2	30.5	98.7	98.7	93.3	89.5
35.2	99.2	96.6	98.0	99.0	35.2	96.5	99.3	99.3	95.0
90.0	98.8	99.2	99.5	98.6	40.0	94.7	96.5	97.1	95.5
44.8	96.0	97.4	98.3	98.6	44.8	91.9	93.3	96.9	98.5
49.9	92.1	91.8	94.3	99.8	49.9	90.0	89.8	94.1	99.7

TABLE II — Effect of Bulb Temperature on Parameters of T12 Lamps.

(Figures are Per Cent of Maximum at Each Current)

Temp.	Volts	Watts	Lumens	lpw	Temp.	Volts	Watts	Lumens	lpw
I. At 500 ma					V. At 250 ma				
21.0	99.0	92.5	72.5	73.6	21.0	100.0	99.5	81.2	93.8
25.0	99.5	98.5	85.4	84.6	25.0	98.8	98.9	90.4	87.5
29.8	99.9	99.9	95.0	94.1	29.8	98.0	98.7	97.5	94.6
35.0	99.4	99.5	99.6	97.8	35.0	97.1	97.6	100.0	98.1
39.9	97.9	98.5	99.8	99.7	39.9	95.5	95.7	99.5	99.6
45.0	95.4	95.8	97.5	99.5	45.0	92.9	93.3	96.7	99.3
49.7	92.5	93.0	92.8	97.6	49.7	90.4	90.5	92.7	98.3
II. At 400 ma					VI. At 200 ma				
21.0	98.6	98.3	75.8	76.5	21.0	100.0	99.6	85.5	84.5
25.0	99.3	99.1	85.5	84.7	25.0	99.8	99.8	92.3	89.5
29.8	99.5	99.9	95.5	93.5	29.8	99.1	99.8	98.4	95.3
35.0	99.1	99.6	99.8	99.3	35.0	97.3	98.5	100.0	98.2
39.9	97.0	98.0	99.7	99.9	39.9	95.5	96.3	99.4	99.9
45.0	95.2	96.7	97.2	99.4	45.0	93.1	94.7	97.0	99.6
49.7	91.8	92.9	92.6	98.0	49.7	90.7	91.6	93.5	98.7
III. At 350 ma					VII. At 150 ma				
21.0	100.0	98.9	78.0	77.3	21.0	100.0	99.5	88.0	86.5
25.0	100.0	99.0	87.5	85.8	25.0	99.5	99.8	93.5	92.1
29.8	99.9	99.8	96.3	93.7	29.8	98.4	99.3	99.1	95.4
35.0	99.1	99.6	99.9	97.6	35.0	96.6	97.3	99.9	98.2
39.9	97.2	97.0	99.7	99.7	39.9	94.1	95.0	98.7	99.3
45.0	95.0	94.9	96.9	99.3	45.0	91.9	92.2	96.2	99.7
49.7	90.2	92.2	92.7	97.8	49.7	90.2	90.6	93.1	97.9
IV. At 300 ma					VIII. At 100 ma				
21.0	100.0	99.7	79.9	79.0	21.0	100.0	100.0	90.9	88.6
25.0	99.5	99.6	89.1	86.8	25.0	99.3	99.8	94.8	90.4
29.8	99.0	99.6	97.0	94.4	29.8	98.0	98.8	99.1	95.9
35.0	98.8	98.9	100.0	98.1	35.0	95.4	96.4	98.8	97.6
39.9	96.2	97.4	99.7	99.8	39.9	93.3	94.0	97.8	99.1
45.0	93.6	94.6	97.0	99.5	45.0	91.2	91.9	95.0	98.4
49.7	91.2	91.8	93.1	98.4	49.7	90.1	90.3	92.7	97.6

TABLE III — Effect of Bulb Temperature on Parameters of 40T17 Lamp.

(Figures are Per Cent of Maximum at Each Current)

Temp.	Volts	Watts	Lumens	lpw
I. At 600 ma				
16.6	100.0	99.7	61.1	59.3
20.8	99.1	99.0	74.2	72.7
25.2	98.2	100.0	89.5	86.5
30.4	97.3	98.4	97.2	95.7
35.5	95.4	97.0	100.0	100.0
40.1	93.0	94.0	99.7	103.0
45.5	91.7	92.0	97.6	103.0
II. At 500 ma				
16.6	100.0	100.0	63.6	59.0
20.8	98.4	98.5	77.0	72.5
25.2	96.6	97.2	89.3	85.4
30.4	96.6	98.1	97.8	92.5
35.5	94.9	95.1	100.0	97.5
40.1	93.1	93.0	99.4	99.1
45.5	90.4	91.1	98.6	100.0
III. At 400 ma				
16.6	100.0	100.0	68.0	63.5
20.8	98.0	99.0	81.4	76.8
25.2	96.2	97.5	91.0	87.0
30.4	95.4	96.0	97.0	94.4
35.5	94.1	94.5	100.0	98.5
40.1	92.8	92.8	99.3	99.8
45.5	91.5	91.0	97.5	100.0
IV. At 300 ma				
16.6	100.0	100.0	74.5	68.3
20.8	98.0	98.0	85.3	79.7
25.2	95.6	96.6	92.9	88.1
30.4	93.2	94.0	97.0	94.6
35.5	91.6	92.0	100.0	99.5
40.1	90.5	91.1	99.1	99.8
45.5	90.0	89.7	97.9	100.0

Temp.	Volts	Watts	Lumens	lpw
V. At 250 ma				
16.6	100.0	100.0	82.0	74.0
20.8	97.0	97.7	90.8	84.0
25.2	94.7	95.4	94.3	89.4
30.4	92.4	93.4	98.0	95.0
35.5	90.9	91.7	100.0	98.5
40.1	89.6	90.1	99.5	100.0
45.5	88.8	89.0	98.4	99.8
VI. At 200 ma				
16.6	100.0	100.0	84.3	74.7
20.8	97.0	97.6	91.0	82.7
25.2	94.5	94.8	95.0	88.8
30.4	91.1	92.0	98.0	94.7
35.5	90.0	90.4	100.0	98.0
40.1	88.2	88.2	99.6	100.0
45.5	88.2	88.2	98.5	98.7
VII. At 150 ma				
16.6	100.0	100.0	85.8	74.8
20.8	95.8	96.5	94.4	85.2
25.2	93.0	94.0	96.5	89.7
30.4	89.4	88.8	99.0	97.0
35.5	87.7	88.3	100.0	98.8
40.1	87.0	87.3	100.0	100.0
45.5	86.3	86.8	99.3	99.6
VIII. At 100 ma				
16.6	100.0	100.0	91.0	78.6
20.8	95.3	95.0	95.7	87.0
25.2	94.3	94.2	95.7	87.8
30.4	88.4	88.4	98.8	96.6
35.5	86.6	87.0	100.0	99.4
40.1	87.3	87.0	100.0	99.4
45.5	86.6	86.3	100.0	100.0

TABLE IV — Effect of Bulb Temperature on Parameters of 96T12 (RS) Lamp.

(Figures are Per Cent of Maximum at Each Current)

Temp.	Volts	Watts	Lumens	lpw
I. At 1000 ma				
18.5	79.5	78.6	50.2	64.0
25.8	92.3	91.5	76.0	83.0
30.2	97.8	97.5	90.0	92.4
34.9	100.0	100.0	98.2	98.0
40.0	99.3	100.0	100.0	100.0
45.3	95.6	96.5	95.2	98.6
50.5	91.2	92.3	89.2	96.3
II. At 800 ma				
18.5	82.1	79.6	53.6	67.2
25.8	94.5	93.3	78.0	83.5
30.2	99.3	97.8	91.0	92.7
34.9	100.0	100.0	98.5	98.0
40.0	99.3	99.8	100.0	100.0
45.3	95.2	96.2	95.1	98.7
50.5	89.7	91.8	88.0	95.6
III. At 600 ma				
18.5	84.7	81.5	58.3	72.0
25.8	95.6	94.6	81.3	85.5
30.2	99.4	98.3	93.7	94.7
34.9	100.0	100.0	99.0	98.3
40.0	98.8	99.3	100.0	100.0
45.3	94.9	95.7	94.8	98.6
50.5	89.2	90.8	88.5	96.7
IV. At 500 ma				
18.5	87.2	82.4	60.7	72.0
25.8	97.5	94.6	83.0	85.8
30.2	100.0	99.0	95.2	94.0
34.9	100.0	100.0	100.0	97.7
40.0	97.8	97.7	100.0	100.0
45.3	94.5	94.7	95.2	98.2
50.5	89.0	89.4	88.0	96.1

Temp.	Volts	Watts	Lumens	lpw
V. At 400 ma				
18.5	90.1	85.4	64.6	75.5
25.8	98.3	96.2	84.8	87.5
30.2	100.0	100.0	96.7	96.4
34.9	99.4	100.0	100.0	99.6
40.0	97.7	98.3	98.8	100.0
45.3	94.2	95.0	94.5	98.8
50.5	90.1	90.0	88.5	97.7
VI. At 300 ma				
18.5	91.9	88.0	68.9	77.0
25.8	97.8	97.2	86.4	87.5
30.2	100.0	100.0	96.4	94.6
34.9	98.3	99.7	100.0	98.5
40.0	95.7	97.5	99.0	100.0
45.3	93.0	94.4	94.4	98.1
50.5	89.2	89.8	88.4	96.8
VII. At 200 ma				
18.5	97.0	93.0	75.8	79.4
25.8	99.5	98.5	88.8	88.0
30.2	100.0	100.0	97.2	94.8
34.9	98.0	98.8	100.0	98.5
40.0	96.5	96.8	99.2	100.0
45.3	94.0	93.7	96.0	100.0
50.5	90.3	90.4	91.6	99.0
VIII. At 100 ma				
18.5	—	—	87.2	81.4
25.8	98.7	100.0	92.6	88.1
30.2	100.0	100.0	92.6	92.8
34.9	96.8	97.5	100.0	97.6
40.0	95.9	94.8	100.0	100.0
45.3	94.5	93.9	98.4	99.9
50.5	94.0	92.2	96.8	99.8

TABLE V — Effect of Bulb Temperature on Parameters of 90T17 Lamp.

(Figures are Per Cent of Maximum at Each Current)

Temp.	Volts	Watts	Lumens	lpw
I. At 1600 ma				
18.6	81.5	80.6	48.3	58.9
25.4	89.4	89.4	69.6	76.9
30.1	96.7	96.0	87.6	90.0
35.4	100.0	100.0	96.1	94.6
40.2	99.3	98.6	100.0	100.0
45.1	98.5	99.6	99.7	99.9
50.0	97.9	98.6	94.0	94.1
II. At 1400 ma				
18.6	81.8	81.3	49.9	60.6
25.4	89.8	90.1	71.6	79.6
30.1	96.0	96.0	87.4	90.0
35.4	100.0	100.0	96.5	95.1
40.2	98.6	98.8	100.0	100.0
45.1	97.7	98.8	97.7	97.8
50.0	95.9	97.2	93.5	94.8
III. At 1200 ma				
18.6	82.6	81.9	52.6	63.3
25.4	90.5	90.1	75.2	82.1
30.1	96.6	95.8	87.7	90.2
35.4	100.0	100.0	97.9	96.5
40.2	98.7	98.4	100.0	100.0
45.1	96.6	97.9	97.3	98.0
50.0	94.5	95.2	92.7	96.0
IV. At 1000 ma				
18.6	93.7	83.5	56.4	66.4
25.4	91.0	91.3	77.3	83.2
30.1	96.8	96.5	88.2	89.7
35.4	100.0	100.0	100.0	98.5
40.2	98.0	98.3	100.0	100.0
45.1	95.2	97.2	97.4	98.8
50.0	92.5	94.0	91.5	96.0

Temp.	Volts	Watts	Lumens	lpw
V. At 800 ma				
18.6	85.0	84.7	59.5	68.4
25.4	91.9	92.4	76.7	81.0
30.1	97.1	96.7	86.8	87.3
35.4	100.0	100.0	95.9	93.3
40.2	96.6	97.5	100.0	100.0
45.1	93.1	95.5	92.6	94.2
50.0	90.4	91.0	87.0	93.1
VI. At 600 ma				
18.6	87.2	87.1	62.5	69.4
25.4	93.2	93.7	74.9	77.2
30.1	97.7	97.0	84.8	84.5
35.4	100.0	100.0	88.4	85.5
40.2	93.4	96.3	100.0	100.0
45.1	89.8	93.0	85.2	88.5
50.0	87.1	87.0	80.5	88.8
VII. At 400 ma				
18.6	90.4	91.3	71.9	78.7
25.4	94.7	96.1	81.1	84.5
30.1	98.5	97.5	89.7	92.1
35.4	100.0	100.0	100.0	100.0
40.2	87.5	94.0	85.4	90.8
45.1	84.3	88.5	82.4	93.4
50.0	81.8	84.2	79.0	93.9
VIII. At 200 ma				
18.6	92.7	98.2	73.6	75.0
25.4	96.1	98.7	90.4	91.5
30.1	98.4	99.2	92.8	93.8
35.4	100.0	100.0	100.0	100.0
40.2	79.7	89.0	66.3	74.8
45.1	77.3	79.7	62.3	78.4
50.0	75.1	66.4	57.6	87.0

TABLE VI — Maximum Values of Parameters of Lamps in Previous Tables.

ma	Volts	Watts	Lumens	lpw
I. 15T8				
500	50.0	21.5	1010	47.2
400	53.5	18.4	894	48.6
300	57.5	15.0	750	50.7
200	63.2	11.05	646	58.4
100	72.0	6.4	358	59.7
II. 30T8				
500	97.0	41.1	2165	53.3
500	102.0	34.8	1904	54.8
300	111.0	28.7	1579	56.8
200	121.0	20.8	1193	60.2
100	136.7	11.3	712	65.7
III. 15T12				
500	45.0	20.7	809	39.3
400	48.0	17.3	699	40.6
300	50.0	13.7	566	41.9
200	54.2	10.0	413	42.1
100	63.0	5.9	257	44.5
IV. 20T12				
500	58.2	26.5	1172	44.9
400	61.0	22.2	1004	45.7
300	64.5	17.7	818	46.8
200	67.3	12.4	594	48.4
100	73.8	6.9	332	49.7
V. 40T12 (Preheat)				
500	103.7	46.9	2635	58.6
400	109.0	39.2	2280	60.3
300	116.0	31.0	1825	62.5
200	124.2	22.0	1323	64.1
100	134.0	11.5	730	68.1

ma	Volts	Watts	Lumens	lpw
VI. 40T12 (RS)				
500	104.8	47.2	2635	57.2
400	110.0	39.3	2270	59.0
300	117.2	31.2	1825	60.3
200	126.8	22.2	1334	62.7
100	139.0	13.0	739	66.6
VII. 96T12 (RS)				
1000	136.0	117.0	7675	65.6
800	145.0	100.3	6740	67.4
600	157.0	81.7	5590	69.0
400	172.0	60.0	4150	69.5
200	195.0	34.5	2320	68.9
VIII. 40T17				
600	108.0	60.7	2695	45.8
500	112.7	53.0	2360	48.1
400	117.5	44.	1978	48.2
300	124.5	34.9	1570	49.1
200	135.0	25.0	1053	47.5
100	150.0	13.8	512	43.0
IX. 90T17				
1600	67.3	98.4	3936	40.6
1400	69.8	90.2	3730	41.9
1200	72.7	81.0	3435	43.0
1000	76.5	70.2	3080	44.6
800	81.6	59.2	2760	47.8
600	89.1	47.3	2430	53.2
400	102.0	35.3	1850	52.3
200	123.0	22.6	1250	55.2

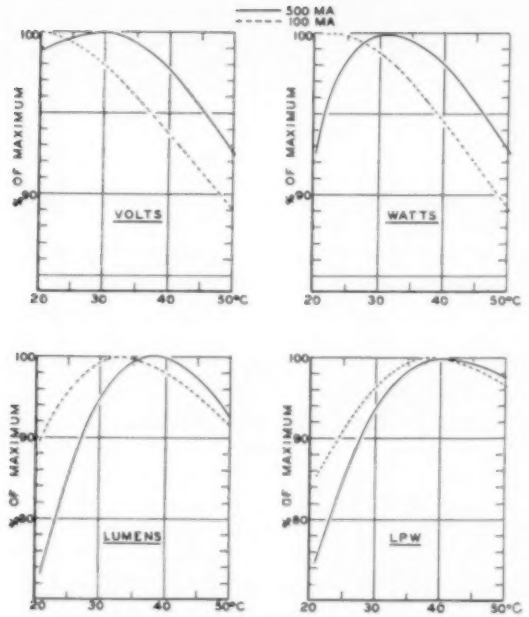


Figure 4. Effect of bulb wall temperature on electrical and luminous parameters of T-8 lamps.

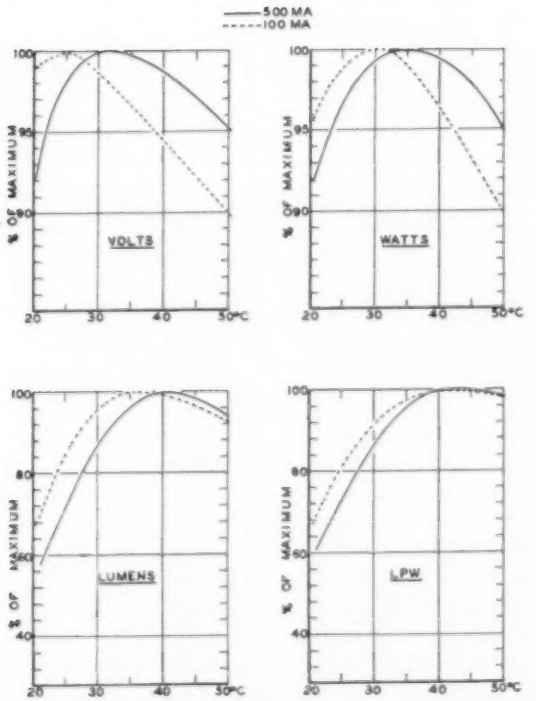


Figure 5. Effect of bulb wall temperature on electrical and luminous parameters of T-12 lamps.

taken by Holden. That is, his experiments were conducted at a constant line voltage and ballasting, while the present data were taken at a constant current. This comparison indicates the desirability of extending this study to both higher and lower temperatures although it is felt that the present range covers most of the practical temperatures of major interest.

The volts and watts of the T-17 lamps (both the 40T17 and 90T17) (see Figs. 6 and 8) vary with temperature differently than either the T8 or the T12 lamps at low currents. These parameters in the T17 lamps fall off more rapidly on the high

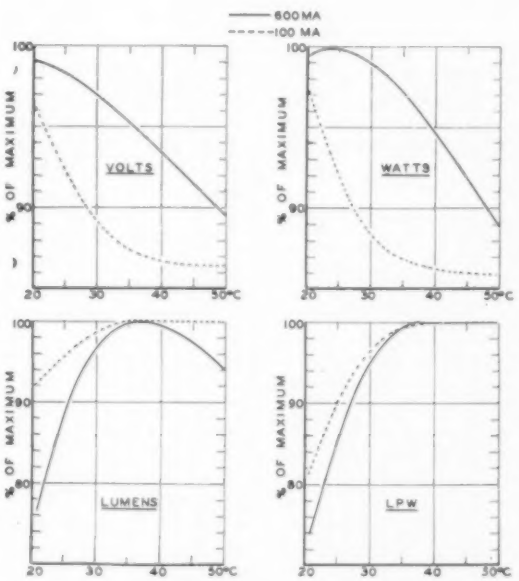


Figure 6. Effect of bulb wall temperature on electrical and luminous parameters of a 40T17 lamp.

temperature side of the maximum and then tend to level off. These data plus the low current variation in lumen output shown in the figures indicate that at these low currents in the large bulb, the arc is verging on an unstable state. The tabulated data for these lamps indicate that "normal" variation is obtained at approximately 300 ma. It would be interesting to determine whether the involution of the luminous efficiency curve for the 90T17 lamp at 200 ma indicates an additional real maximum. However, if the unstable arc explanation is accepted, then it follows that the involution shown is due to variations in the lamp parameters caused by the instability of the arc rather than any real effect of the temperature.

It would be dangerous to try to draw general

conclusions from measurements on individual lamps such as are included in this study, even though the method of presentation adopted here gives more than one set of measurements in the T-8 and T-12 classes. To be strictly rigorous, several lamps of each size should be measured. However, Drs. Bitter and Waymouth of our laboratories have carried out a theoretical analysis of the plasma of fluorescent lamps[4] which had led to results which agree very well with those presented here. Bolstered by this theory, the following conclusions are stated with a fair amount of certainty.

1. With increasing current, all the parameters measured reach their maxima at higher bulb wall temperatures.

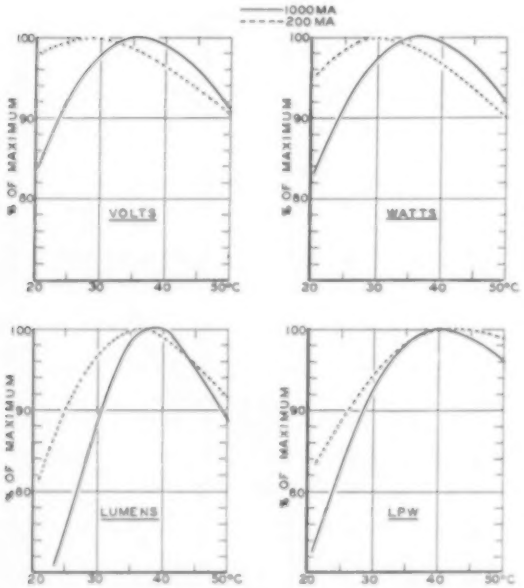


Figure 7. Effect of bulb wall temperature on electrical and luminous parameters of a 96T12 (RS) lamp.

2. The larger the bulb diameter the higher the bulb temperature at which maximum efficiency is attained.
3. Argon filled lamps reach their maximum efficiency at higher bulb wall temperatures than do Krypton filled lamps.

However, it is hoped that the real practical application of these data will be in the prediction of the operating parameters of a fluorescent lamp at any ambient temperature and current, if those at any other temperature and current are known. For example, the comparative data in Table VII were computed for the lamps in question from the tabulated data herein by the following steps:—

1. From the rated operating current for the lamp in question, the difference between bulb and ambient temperatures was determined from Fig. 2. From this datum, the bulb temperature corresponding to each ambient was determined.
2. The per cent of maximum data for the lamp at the rated current at each bulb temperature was determined by direct interpolation between data in the tables.
3. The data at specific bulb temperatures were then determined by direct interpolation from the temperature data obtained in step 2 above.

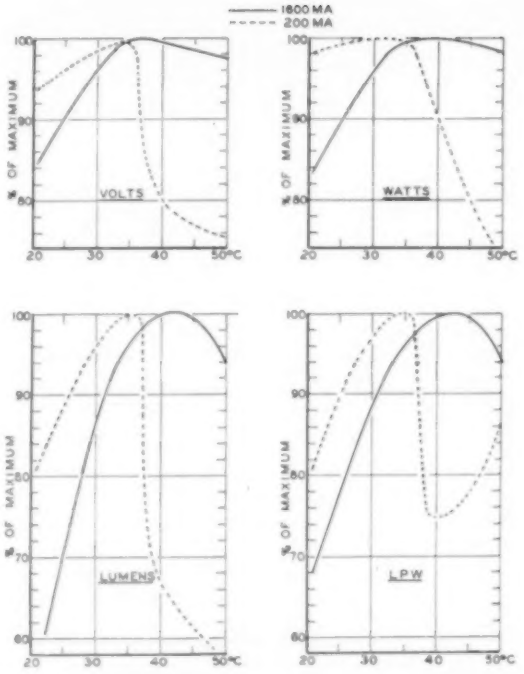


Figure 8. Effect of bulb wall temperature on electrical and luminous parameters of a 90T17 lamp.

If data at currents beyond the range studied here are desired, plotting the tabulated data as a function of current at constant bulb temperatures will allow extrapolation for short distances. For example, suppose a 40T12 lamp operates at 68.0 lpw at 400ma and 25°C ambient temperature and it is desired to find what efficiency to expect at

TABLE VII — Comparison of Data from This Study with Those of Holden.[5]

Ambient °F	Temp. °C	40T12 (Reheat) (ΔT = 17°C) lpw (% of Max.) Bulb Temp.	(% of Max.)	From Holden	90T17 (ΔT = 23°C) lpw (% of Maximum) Bulb Temp.	This Study	Holden
30	−1.1	15.9°C	64.2	40.0	21.9°C	85.5	48.0
40	4.4	21.1	75.6	75.0	27.4	92.5	65.5
50	10.0	27.0	88.5	89.0	33.0	98.4	81.0
60	15.6	32.6	96.4	97.5	38.6	99.3	93.0
70	21.1	38.1	99.4	100.0	44.1	98.3	100.0
80	26.7	43.7	99.5	98.5	49.7	97.0	97.0
90	32.2	49.2	98.1	96.5	55.2	95.6	91.5
100	37.8	54.8	96.3	93.5			

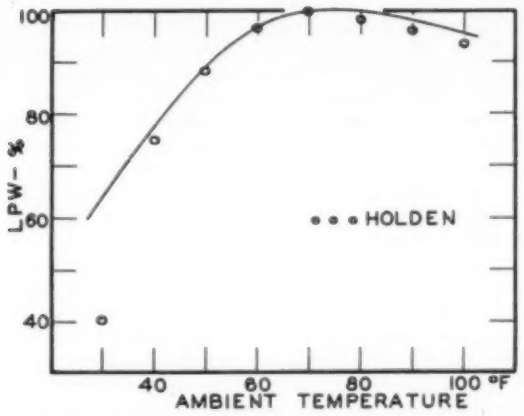


Figure 9. Comparison with Holden's data for 40T12 lamp.

600ma and 0°C ambient. The following steps are involved:

1. From Fig. 2, ΔT at 400ma = 17°C; at 600 ma = 21°C (extrapolation). Therefore, bulb temperatures in this example are 42°C and 21°C respectively.
2. Plotting the data in Table II as a function of current at constant bulb wall temperature and extrapolating out to 600ma, and further extrapolating between the curves for 40°C and 21°C, it is found that at 400ma and 42°C bulb temperature, the luminous efficiency is 99.7 per cent of its maximum at that current, while at 600ma and 21°C bulb, it is 69.6 per cent of its maximum at that current.
3. Plotting the maximum lpw for 40T12 lamps as given in Table VI as a function of current and extrapolating out to 600ma, it is found that at this current the maximum lpw is 57.0.
4. In Step 2, it was found that this lamp should operate at 69.6 per cent of its maximum at 600ma, or, using the maximum value found in Step 3, it should operate at 39.7 lpw.
5. Our present lamp operates at 68.0 lpw at 400ma. That is, its maximum lpw at this current must be $\frac{68.0}{.997}$ or 68.2 lpw, as against 60.3 for the lamp in Table VI. Therefore, the 39.7 lpw reached in Step 4 must be increased by the ratio 68.2/60.3, or to 45 lpw. (This is assuming that if the lpw of a lamp is a certain percentage of the tabulated data at any point, it will keep the same relative difference at any other point.)

There is considerable danger of error in trying to extrapolate these data very far beyond the observed range. However, these examples do illustrate some of the hoped for applications for these data and it is hoped that they will be useful to the lamp design engineer.

Bibliography

1. Lowry, Gungle, Jerome: "Some Problems Involved in the Design of Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XLIX, No. 11 (November 1954).
2. Marden, Beese, Meister: "Effect of Temperature on Fluorescent Lamps," *Transactions I.E.S.*, Vol. XXXIV, No. 1 (January 1939).
3. Thayer, Barnes: "The Basis of High Efficiency in Fluorescent Lamps," *J.O.S.A.*, Vol. 29, p. 131 (1939).
4. Waymouth, J. F., and Bitter, F.: "An Analysis of the Plasma of Fluorescent Lamps," *Bull Amer. Phys. Soc.*, 30, p. 9 (January 27, 1955) (Abstracts B1 and B2).
5. Holden, C. M.: "Effect of Ambient Temperature on Light Output of Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 12 (December 1953).
6. Forbes, Diefenthaler: "Effect of External Factors on Light Output of Fluorescent Sources," ILLUMINATING ENGINEERING, Vol. XLI, No. 12 (December 1946).

DISCUSSION

R. N. THAYER:* The test method and data appear admirably complete. Mr. Jerome's results agree satisfactorily with unpublished data which we obtained similarly by water-bath tests on T8 and T12 sizes at their rated currents. We offer comment on three points:

(1) In the water-bath test method, the entire bulb-wall is held at the same temperature, whereas in normal lamp operation in air, the lamp ends are hotter than the center. Since the lower temperatures at the center in air burning are commonly considered to determine mercury vapor pressure, and so light output, there should be exact correspondence between light output values obtained from the lamp burned either way, if minimum bulb temperature is the same. But in a test we ran comparing the two methods, light output was 2 to 5 per cent lower for air-burning than for water-bath, for the same center bulb temperature. So, under actual burning conditions, there may be minor departures from water-bath test results.

(2) The data of Fig. 2 should be convertible to approximately a single straight-line relationship if the increase of bulb-wall temperature over ambient is plotted against the watts of arc energy dissipated per unit area of bulb-wall surface. The Forbes-Diefenthaler paper at the 1946 I.E.S. Conference (ILLUMINATING ENGINEERING, Vol. XLI, page 872, 1946) demonstrated this, and showed the slight variations from this generalization that occur with varying bulb diameters. These variations can be explained and calculated on the basis of a thin film of stationary air around the bulbs.

(3) The curves of voltage and wattage in this paper commonly show a maximum in the 30-40 degree range, then a decline in the 20-30 degree range. Our tests in argon-filled lamps indicate that the shape of this curve is quite dependent on the filling pressure of the gas. At pressures of 4 mm or more, both of these curves continue to rise steeply at lower temperatures. But if filling pressure is relatively low, such as the 2.5 mm value used in our low-temperature lamps, the decline in volts and watts is steep at low temperatures. We believe this contributes to their easier starting and arc maintenance in cold weather, over lamps of the standard 3 to 3.5 mm pressure. What are the values of filling pressure of starting gas on the lamps used in his tests?

*Large Lamp Dept., General Electric Co., Nela Park, Cleveland, Ohio.

A. W. Weeks:* Mr. Jerome has presented the results of an exhaustive study. It would be difficult to say whether the accumulation of data, or the work necessary to present these data, was the greater task. That is unimportant, but it is important that the lamp engineer has been provided with a set of working tools which will enable a reasonably accurate prediction of the characteristics of any proposed fluorescent lamp design.

I would like to raise one question and suggest a possible refinement in event the author will be able to continue this work.

Bulb wall temperature was measured with a single thermojunction located approximately in the middle of the lamp. The bulb wall temperature varies considerably over the length of the lamp and possibly between the top and bottom. This will be particularly true under the condition of still air. The average bulb wall temperature can be measured by wrapping the lamp under study with fine copper wire (#40 is suitable). The wire may be secured by applying a bit of clear nail polish at intervals along the turns. The turns may be spaced sufficiently far apart so that relative light output under different conditions can be obtained. A measurement of the resistance of this copper wire at some known temperature will permit the determination of other temperatures by the resistance-temperature coefficient of copper.

Data using mean bulb wall temperature might serve to throw further light on this problem.

I congratulate Mr. Jerome on the presentation of a splendid paper.

Ward Harrison:** The data given in this paper are helpful and they emphasize the fact that at low temperatures the candlepower of fluorescent lamps drops off markedly. Figs. 4 to 7 would also suggest that they seldom lose more than 5 or 10 per cent due to overheating. On the other hand, I have measured some 96-inch RS lamps in enclosed luminaires which fell off fully 30 per cent due to overheating when operated in a room not over 72F. This is about the simplest photometric test that one can be called upon to make, but I have rarely seen it done in the field. All that is needed is to place a footcandle meter under a fixture and then turn the lamp on. Normally the needle continues to rise for several minutes and may remain at a point on the upside of the curve. However, if the fixture runs too hot the needle will soon pass through a maximum and start to fall off. Sometimes the extent of the drop will surprise you. I believe that the curves of at least Fig. 7 should be carried further on the high temperature side.

Miles Pennybacker:† Mr. Jerome's excellent paper will be very helpful to the lamp designer as well as to the many others concerned with the effect of fluorescent bulb temperatures on lamp efficiency.

My concern is that some people might be misled by those charts, Fig. 4 through Fig. 8, which show the effect of bulb wall temperatures on lumens per watt. From these charts it does not appear that the lumens per watt at low currents are markedly greater than at high currents. This is because Mr. Jerome plots temperatures against per cent of maximum, instead of directly against lumens per watt. If the latter had been done, it would have been clearer at which temperature the peak efficiency came, as it is for T12 bulbs in Fig. 3.

*Champion Lamp Works, Lynn, Mass.
**Consulting Engineer, Cleveland, Ohio.
†Voltarc Tubes Inc, Norwalk, Conn.

For example, in Fig. 4 there is no indication that the peak lumens per watt at 100 ma is more than 20 per cent higher than that at 500 ma, when the temperature of the bulb is held at optimum by a water bath. (In ordinary room air the actual difference in efficiency is of course much greater because the bulb temperature at high currents then goes far above optimum.) I think it unfortunate that this concept has to be dug out of the tables, when it could have been made clear quite simply either in words or on the charts.

My other point relates simply to the question as to whether any check had been made to determine the effect on fluorescent lamp parameters of mercury migration away from the ends of the lamp. This is a familiar phenomenon on d-c and, from experience on mercury tubes in neon signs, it would appear that it occurs to some extent on a-c, becoming more pronounced as the ambient temperature goes downward with prolonged life. Hence, it raises a question as to whether a measurement of footcandles near the center of a long lamp that has run several thousand hours can be calibrated properly to correspond with total lumen output at various temperatures.

C. W. Jerome:* I would like to thank the various commentators for their interest in this work. It is particularly gratifying to see that considerable thought is still being given to the effect of temperature on fluorescent lamp behavior.

Burning a fluorescent lamp completely immersed in water is an entirely artificial set-up. However, it does furnish the easiest means for accurate control of bulb-wall temperature. Minor departures from normal, in-air burning should be expected, but these should be small and should not affect appreciably the trends in the various parameters as they change with changing temperature.

Fig. 2 was drawn in the form in which it appears in the paper as being more practically useful. It is true that a single relationship can be drawn which will be approximately valid for all lamp sizes, but the conversion of its data for any particular size requires an additional calculation which the present figure obviates.

The fill pressures of the lamps used are stated in the caption to Fig. 2, that is, the normal 3.0 mm pressure used in our production lamps. The exceptions are the 96T12 RS and the 90T17 lamps whose pressures are also indicated in the caption.

Mr. Weeks' suggestion for a means of measuring the average bulb temperature over its full length is an excellent one and a worthwhile tool for a researcher to have available. However, as has been observed by others, it is the minimum temperature in the lamp that is usually conceded to establish its operating characteristics. In this case, a single temperature measurement at the coolest point of the lamp should give the more useful data.

I agree with Dr. Harrison that high temperatures also have a bad effect on the light output of fluorescent lamps, and they are more frequently encountered in normal operation. This is a condition that we have tried to point out in all our recent publications (see Reference 1 and I.E., Vol. XLIX, p. 237, May 1954). It is the reason for our stressing the need for good ventilation in all fluorescent lamp fixtures except those for low temperature applications. Some idea of the effect of high temperatures on 40T12 lamps can be seen in the reference cited above. In view of the similarity of the data for most of the lamps tested it is ex-

*Author.

pected that the 96-inch RS lamp will behave like the 40T12 lamps studied in that reference.

Mr. Pennybacher's comment on the method of presentation of these data is quite valid. However, as pointed out in the paper, there are so many data here that some condensation was essential and no matter how they are given some items would have to be neglected. This problem was given a great deal of thought and the compromise presented was deemed the best. The essential thing is that all the data are there and can be dug out and arranged in any manner which will best meet the particular needs of anyone onterested.

We have not encountered any difficulty with fluorescent lamps due to mercury migration during operation on a-c. It is true tnat very close to the end of life one cathode may become deactivated before the other giving rise to considerable rectification in the lamp. In this case it would operate very much as if on d-c and cause mercury migration. However, this phenomenon occurs so close to the end of life that the lamp will usually burn out before the migration effects become noticeable. This condition may be aggravated in neon signs because the low ambient temperatures in which they are usually run, slow down the rediffusion of mercury. The higher ambient temperatures of normal operation of fluorescent lamps which help speed up the diffusion of mercury throughout the lamp may be one of the reasons why this phenomenon has not caused any great trouble in their operation.

Lighting an All-Around Maintenance Area

The shop area of this cement block building, 59½ ft by 44 ft in size, is used for maintenance work, including welding, machining, pipe work, fabrication, carpentering and all portable maintenance problems of the S. B. Foot Tanning Co., Red Wing, Minn.

Ceiling height is 18 ft 6 inches with steel ceiling beams across the width of the building, leaving 16 feet from beams to floor. The beams support the ceiling, to leave floor area clear, and also will provide a means for installing an overhead crane system.

Lighting units chosen are 5-foot industrial fluorescent fixtures using two 90-watt T-17 lamps. The units have all-white, removable vitreous porcelain enamel reflectors, to deal with corrosive vapors present in tanneries, and 10 per cent uplight. They are mounted between the beams in six rows of eight fixtures on eight-foot centers.

At the end of 600 burning hours, illumination was from 125 to 175 ft-c on a sunny afternoon. After 1700 burning hours, it was 90 to 125 ft-c on a dark rainy morning. The only windows are on the west side of the building.

Installation designed by Raymond J. Palus, Northern States Power Co., and Harvey Glanser, S. B. Foot Tanning Co., both of Red Wing, Minn. Electrical contractor was Kask Electric Co., also of Red Wing.

Phosphor Stabilization For Better Lamp Performance

By HORACE H. HOMER
KEITH H. BUTLER
MARTHA J. BERGIN

After the introduction of a new light source, continuous efforts have always been made to improve its light output and its lumen maintenance. The user of any light source is concerned not only with how much light he will get initially, but also with how long he can expect to get an adequate light output. One needs only to look back a few decades to be impressed by the tremendous efforts expended on the improvement of these two properties in the incandescent lamp. The history of the development of the fluorescent lamp reveals a similar effort, but the advances appear to have been more rapid. Of especial significance, with the advent of the long-life fluorescent lamp, has been the factor of long term maintenance. A long lamp life is of little value if the light output has fallen off seriously during lamp life.

Historical

From the early days of the fluorescent lamp the problem of lamp maintenance has been the subject of much study. This loss of light output with lamp life has been shown to be the result of complex factors: the condition of the phosphor, the processing of the lamp and the inherent characteristics of the lamp itself all played their part in determining the lamp performance. That much was done to improve the performance is demonstrated in Fig. 1.[1] This shows that a gradual improvement both in lamp efficiency and maintenance took place over the early years of lamp development. A study of the changes which occurred during this time shows that much of this advancement in performance was brought about by improved techniques for preparing the phosphors themselves. Changes in chemical formulae, new firing procedures and elimination of impurities all contributed. Also contributing, but to a less significant extent, were improved procedures for processing the lamp itself. Of special importance is the gain which occurred between 1946-47 for it was at this time that a technique was introduced which played a considerable part in the development of the method for improvement of lumen output and maintenance to be described in this paper.

Early in the development of the fluorescent lamp it was found that the presence of inorganic materials in the glass could adversely affect phosphor performance. This knowledge was brought about by the observation of the greatly impaired maintenance when lime glass bulbs replaced the lead glass used previously. This difficulty was traced to the presence on the inside surface of the bulb of inorganic salts which reacted with the phosphor. A thorough washing of the bulbs before coating removed the offending materials, but did not prevent the slow evolution of deleterious compounds from the glass during lamp life. A method of protecting the phosphor from this adverse chemical reaction was desirable. A technique was developed in which a small amount of an oxide of antimony was mixed with the phosphor coating solution.[2] During the processing of the lamp the antimony oxide apparently coated the glass surface and the phosphor crystals, providing a protective layer

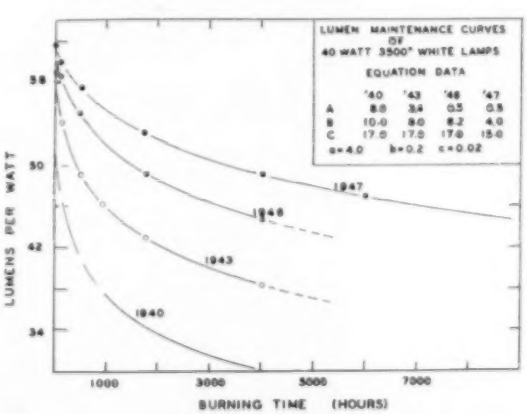


Figure 1. Improvements in efficiency of 40-watt T12 3500° white lamps from 1940 through 1947.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 12-16, 1955, Cleveland, Ohio. Authors: Sylvania Electric Products Inc., Salem, Mass.

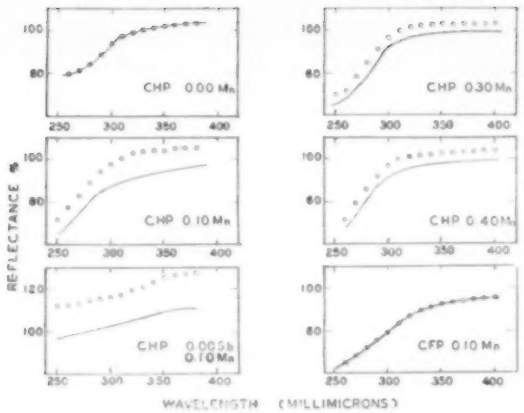


Figure 2. Effect of chemical treatment on surface reflectance of various phosphate phosphors.
ooo — Treated phosphor
—— — Untreated phosphor

which substantially resisted the evolution and reaction of the deleterious compounds. In addition it was found that this technique provided a means of protecting the phosphor from the harmful effects of the 1849A radiation occurring in the mercury arc.

The observation of these phenomena in conjunction with other studies on lamp behavior led Butler and Lowry to propose a mathematical expression for the loss of light output with lamp life.[3] They have shown that for zinc beryllium silicate phosphors the maintenance of the fluorescent lamps can be explained by three mechanisms occurring concurrently during the life of the lamps:

First mechanism — gaseous impurities remaining in the lamp after exhaust reacting with the phosphor.
Second mechanism — solid state reaction between the phosphor and impurities in the phosphor and on the glass wall.
Third mechanism — photochemical deterioration of the phosphor caused by 1849A radiation in the arc.

This, they have shown, can be expressed mathematically in the form of a typical reaction rate equation as follows:

$$L_o - L_t = A(1-e^{-at}) + B(1-e^{-bt}) + C(1-e^{-ct})$$

where L_o = initial efficiency in lumens/watt
L_t = efficiency at any time t
t = operating time in hundreds of hours
A, B and C — representative of amount of impurities present expressed as lpw
a, b and c — are quantities expressing the rate of the reactions.

When the data on the early lamp improvements prior to the introduction of the antimony oxide are examined in the light of the Butler-Lowry equation, a significant aspect of the gains made during this period is seen; they were made for the most part in the lumen maintenance between 100 and 1500 hours of lamp life. The phosphor had been made more resistive to the deleterious effects of contaminations. Very little improvement in initial output and no change in the slope of the maintenance curves beyond 1500 hours was observed. In terms of the Butler-Lowry equation this means that the gains occurred mainly in the A and B terms with the C term remaining essentially constant.

For the gains in lamp performance occurring with the use of the protective coating of the antimony oxide, however, the A term remains constant and the protection against the evolution of the contaminants from the glass shows up as a reduction in the B term. While the retardation of the deterioration of the phosphor by the 1849A radiation is manifested by a reduction in the C term.

The above was true for the lamps made from zinc beryllium silicate phosphors. With the commercial advent of the calcium halophosphate phosphors, however, it was found that the maintenance equation was still valid. Much the same deterioration processes were apparently occurring, but the antimony oxide treatment had little, if any effect.

This paper will describe a chemical treatment for the calcium halophosphate phosphors which materially increases both the initial light output and the long term maintenance of fluorescent lamps.

Experimental

The fact that the addition of antimony oxide had a lesser effect on the performance of calcium halophosphate phosphors led to a study of the surface layers of these phosphors and the role of these layers in phosphor performance. It seemed possible that these layers might contain materials which could affect the absorption of the 2537A radiation by the phosphor and their presence should be indicated when the phosphor was irradiated with 2537A. A logical method for testing this hypothesis would be to remove by some means the surface of the phosphor and with it the suspected layer, testing the brightness of the irradiated phosphor before and after treatment.

A variety of procedures for the removal of this suspected layer were investigated. It was observed that the brightness of the phosphor when irradiated by 2537A was improved when certain chemical techniques for the removal of the surface layer were followed. It was also found that there apparently was no advantage gained by using reducing media, thus indicating that the effect was one of

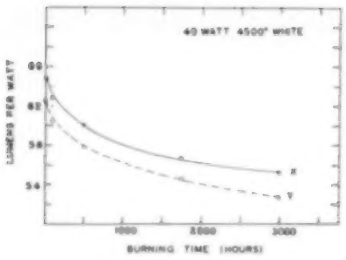


Figure 3.

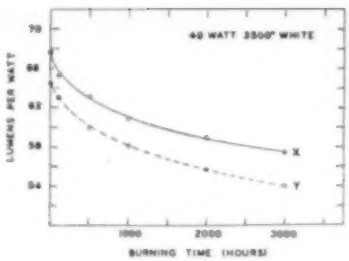


Figure 4.

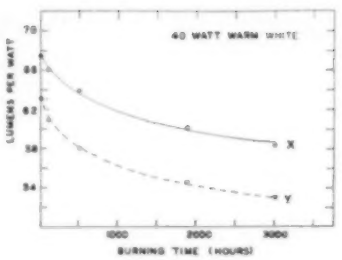


Figure 5.

Effect of "stabilization" of the phosphor on lamp efficiency of 40-watt T12 lamps.
Curve *X* — Stabilized phosphor
Curve *Y* — Unstabilized phosphor

solution of surface layer rather than the reduction of manganese. A standard technique was decided upon for test purposes.

Measurements made on various halophosphate phosphors, so treated, indicated that an improvement in brightness did occur and that the degree of improvement varied from about one to ten per cent. The magnitude of this improvement was generally observed to have a correlation with phosphor composition. Results with representative phosphors are shown in Table I.

It was further reasoned that there might be differences in the reflectance from treated and untreated phosphors. To investigate this possibility,

TABLE I — Observed Effect of Treatment of Representative Halophosphate Phosphors.

Phosphor	Brightness before treating*	Brightness after treating*
Blue halophosphate	122	123.5
4500° white	115.5	118.7
3500° white	104.0	108
Warm white	92	98.8

*Brightness measurements were made with a 1P20 photomultiplier without a Viscor filter.

a series of absorption measurements were made with a Beckman DU spectrophotometer using a radiation range from 2500A to 4000A. Typical results of this study are shown in Fig. 2. A definite increase in reflectance was observed for the phosphors which had also shown an increase in brightness when irradiated by the 2537A. It was clear from both the brightness and reflectance measurements that an observable change had occurred in the treated phosphors, but the value of such a change could not be determined until lamps were prepared using such phosphors.

Large scale treatment of phosphors was then carried out using a method suitable to manufacturing procedures.[4] Lamps prepared from these treated phosphors confirmed the observation from the brightness and reflectance measurements. In every case the treated-phosphor lamp had improved efficiency over lamps prepared from untreated phosphors and the amount of this increase varied with the particular halophosphate used. There was, however, a further unexpected discovery. Accumulation of a large amount of life data on lamps containing these treated phosphors showed that there was, in addition to the improved initial lumen output, a significant improvement in the lumen maintenance. This markedly improved maintenance indicated that these phosphors had an increased resistance to the deleterious processes normally occurring during lamp life. In other words, these phosphors were "stabilized."

In Figs. 3 to 5 are shown the effectiveness of this "stabilization" process on the performance of lamps prepared with treated phosphors of various commercial colors. These curves represent the averages of several hundred lamps. The increased light output for the "stabilized" phosphor is clearly evident.

Not as easily discernible in these figures but shown in Fig. 6 is the typical effect of the "stabili-

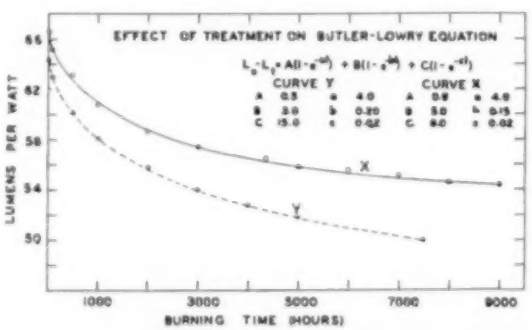


Figure 6. Effect of "stabilization" of the phosphor on the constants of the Butler-Lowry equation.
Curve X — Stabilized phosphor
Curve Y — Unstabilized phosphor

zation" on long term maintenance. This figure gives the results of a test on a group of thirty 3500° white 40-watt lamps which were picked at random from a production run of lamps with "stabilized" phosphor and compared to lamps made with "unstabilized" phosphor. Not only is there a definite increase in the light output of the lamps containing the "stabilized" phosphor, but it can be seen that the slope of the curve for these lamps also flattens perceptibly with lamp life. The long-term maintenance has been definitely improved. The effect of this treatment on the constants of the Butler-Lowry equation will be discussed in a later section.

The explanation of the third term in the Butler-Lowry equation has been given as the photochemical deterioration of the phosphor caused by the 1849A radiation in the low pressure mercury arc. In the low temperature fluorescent lamps in which both the amount of the 1849A radiation and the electron temperature of the arc have been materially increased, due to the lower argon pressure used, the rapid loss of maintenance resulting from this additional amount of radiation energy has always been a problem. If the "stabilization" of the phosphor is a reality this should be evident in an improved maintenance curve for the low temperature lamps. Figs. 7 and 8 show that this is indeed the case. In Fig. 7 is shown the effect that "stabilization" has on the maintenance of low temperature 40-watt 3500° lamps. With the lamps using the "unstabilized" phosphor, curve *Y*, there is the customary high initial efficiency of the low temperature lamps followed by its rapid decline during life. In the case of the lamps using the "stabilized" phosphor, curve *X*, this rapid decline in efficiency has been substantially reduced. In Fig. 8 is shown how this improvement in maintenance affects the comparison of 40-watt 4500° white low temperature lamps with those of regular lamps. With the lamps prepared with the "unstabilized" phosphor their original high efficiency rapidly deteriorates, resulting in a lower value than the standard pressure lamps after about 4000 hours of life. For the lamps prepared with the "stabilized" phosphor, however, the improved maintenance of these lamps has prevented this early cross-over of efficiency value. The efficiency curve of the low pressure lamp will eventually cross that of the normal pressure lamp, but this will not occur until after the rated life of the lamp has been passed.

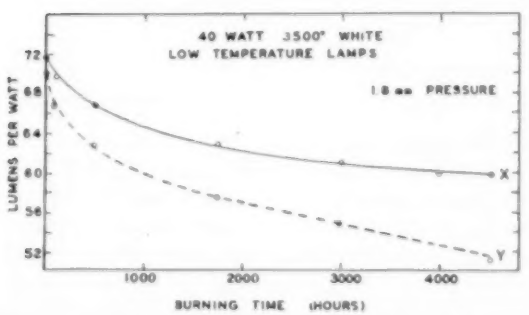


Figure 7. Effect of "stabilization" of the phosphor on maintenance of low-pressure 40-watt T12 3500° white lamps.

Curve *X* — Stabilized phosphor
Curve *Y* — Unstabilized phosphor

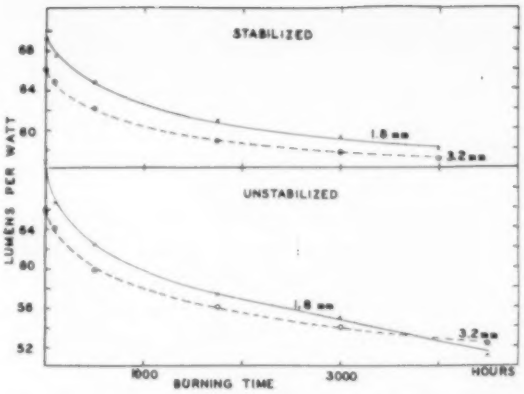


Figure 8. Effect of "stabilization" on the comparison of standard and low-pressure 40-watt 4500° white lamps.

Summary of Experimental Results

1. Initial lumen efficiency of the lamp has been materially increased.
2. Lumen maintenance has been substantially improved.
3. The abnormally rapid deterioration of light output usually associated with low pressure lamps has been eliminated.
4. The above has been accomplished by the "stabilization" treatment of the halophosphate phosphors.

Discussion

From the foregoing summary it is evident that a definite improvement has been made in both the phosphor efficiency and maintenance. When the Butler-Lowry equation is employed to analyze the ramifications of the improvement, several interesting observations can be made. In Fig. 6 was shown the results of a maintenance test on two groups of 40-watt 3500° white lamps. Group *X* has been made with a "stabilized" phosphor with Group *Y* as controls. When the constants for the Butler-

Lowry equation for these curves are calculated these facts stand out. The initial output has been markedly increased and the coefficient of the C term or long term maintenance factor has been improved from 15 to 8, a substantial gain. As a result the whole level of lumen output is raised throughout life.

In contrast the treatment of zinc beryllium silicate with antimony oxide gave a gain in light output primarily due to decrease in the A and B terms while the C term was only slightly reduced and the initial output remained essentially unchanged.

The differences in the two treatments are evident, but what is the mechanism giving this improvement with the "stabilized" halophosphates and what does it mean to the user of the fluorescent lamp? The mechanism is still the subject of intensive investigation, but enough has been established to make possible an understanding of what is taking place.[5] It can be explained as follows:

In the manufacturing of the phosphor the elements of which it is composed are exposed to high temperatures. Under the influence of this high temperature a situation arises at the surface of the newly formed phosphor crystal which can be described as follows. Some of the chlorine present at the phosphor surface will combine with antimony to give a volatile material which vaporizes from the surface. The loss of the chloride is made up by the migration of oxygen atoms into the surface giving rise to the formation of an oxyapatite-type material which is non-fluorescent. In addition, any manganese or similar material which was present in the crystal surface is probably now present in the oxyapatite layer in a dissimilar form to that to be found in the interior of the crystal. In its present form it is an absorbent of the 2537A radiation and to some extent visible light. This property would render it detectable by reflectance measurements. The assumption of this mechanism is strengthened by the observation that phosphors containing either no chlorine or no manganese exhibit very little improved reflectance upon treatment. It follows that the greater the concentration of manganese in the original phosphor, the more will be available to assume a harmful form in the surface layer. The "stabilization" of the phosphor removes a thin layer of the crystal surface carrying with it the deleterious materials. This exposes a fresh crystal surface containing little or none of these non-fluorescent ultraviolet absorbents. Therefore the efficiency of utilization of the 2537A radiation is increased and manifests itself as an increase in light output of the phosphor. Subsequent degradation of some of the new crystal surface may occur during lamp processing, but the amount of absorbent materials present has been so reduced as to insure a more efficient lamp.

The reason for the reduction of the C-term in the Butler-Lowry equation is not as well understood. However, it is believed that in addition to removing a deleterious surface layer, the chemical treatment forms a thin protective layer over the surface of the crystal which serves a similar function to that of the Sb_2O_3 layer on the zinc beryllium silicate phosphors. This material is transparent to the 2537A radiation and produces no reduction in its efficient utilization. It is, however, an excellent absorber for the harmful 1849A radiation and effectively retards its reaching the phosphor crystal preventing the subsequent deterioration of the phosphor efficiency.

The benefits of this "stabilization" of the phosphor to the users of fluorescent lamps are both obvious and far reaching. With one simple technique it has been possible to raise the initial light output levels of the lamps from 4 to 8 per cent depending upon the phosphor color; and at the same time it has been found possible to improve the maintenance with life by about 5 to 10 per cent.

In other words, the initial output has been raised for the lamps containing the "stabilized" phosphor, and this initial gain is increased during lamp life. The magnitude of this gain goes from 4 per cent for the cool white lamps to an increase of 8 per cent for the warm white lamps. What this means is shown in Fig. 9 in which the magnitude of the improvement is demonstrated with 40-watt 3500° white lamps before and after "stabilization." Since the user of the fluorescent lamp is buying light and paying for it both in the initial cost of the lamp and in the cost of the power as the lamp burns, he

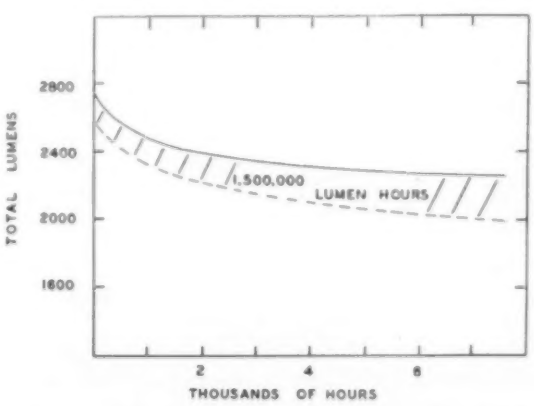


Figure 9. Gain in total lumens produced for 40-watt T12 4500° white lamps made with stabilized phosphor.

is interested in the total amount of light he will get for the money he has spent. Fig. 9 shows us that with a lamp prepared from "stabilized" phosphors he is receiving a gain of 1.5 million lumen hours at no additional cost.

An additional benefit, and one that may become increasingly significant in the future developments of fluorescent lamps, is the effective way in which this treatment provides protection for the phosphor from the rapid deteriorating effects of excessive radiation bombardment, such as that found in heavily loaded lamps. If this deterioration can be effectively retarded, it should be possible to pack more energy into a given lamp size without the normal excessive light loss with a subsequent production of more light. That this can be accomplished is amply demonstrated by the fact that the use of "stabilized" phosphor has been one of the major factors in making possible the successful development of the high efficiency 100-watt 96T12 Rapid Start Lamp.[6]

Summation

We have shown that:

1. A chemical treatment of the halophosphate phosphors will materially increase the lumen output of fluorescent lamps.
2. An improvement occurs both in the initial output and the long-term maintenance, the latter being independent of phosphor composition and manganese content.
3. The net change in the Butler-Lowry maintenance equation is a reduction of the C term.
4. The net effect of the treatment of the phosphor is a considerable increase in lumen hours with no additional cost to the customer.
5. The way has been opened to the practical design of highly loaded lamps without the excessive loss in efficiency previously encountered.

Acknowledgments

The authors wish to express their appreciation for the aid received from the various members of the Enginering Staff of the Sylvania Tungsten and Chemical Division who furnished all the phosphors used in this investigation, to the various members of the Chemical Engineering Department and Photometric Department, Danvers, Massachusetts, for their assistance in running the many tests on the phosphors and to their colleagues in the General Engineering Department at Salem who have assisted in various phases of the investigation.

References

1. Lowry, E. F.: "The Long-Term Deterioration in Certain Phosphors Exposed to the Low Pressure Mercury Arc," *Jour. Electrochemical Society*, Vol. 95, No. 5, p. 242 (May 1949).
2. Lowry, E. F., and Mager, E. L.: "Some Factors Affecting the Life and Lumen Maintenance of Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XLIX, No. 2, p. 98 (February 1949).
3. Lowry, E. F.: "A Study of Fluorescent Lamp Maintenance," ILLUMINATING ENGINEERING, Vol. XLIII, No. 2, p. 141 (February 1948).
4. Butler, K. H., and Homer, H. H. (To Sylvania) U. S. Patent 2,691,601 issued October 12, 1954: "Phosphor Treatment."
5. Bergin, M. J., Butler, K. H., and Homer, H. H.: "Calcium Halophosphate Phosphors II. Optical Properties of the Particle Surface." (Paper presented at the Spring Meeting of the Electrochemical Society, May 1-5, 1955, Cincinnati, Ohio.)
6. Lowry, E. F., Gungle, W. C., and Jerome, C. W.: "Some Problems Involved in the Design of Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XLIX, No. 11, p. 545 (November 1954).

DISCUSSION

C. M. HOLDEN:* This paper illustrates very adequately some of the engineering and research that has resulted in the extreme growth of fluorescent lamps as an economical source of illumination.

Although the information set forth by the author covers in great detail the effect of this new phosphor treatment on initial efficiency and lumen maintenance, it is evident that that treatment itself was purposely omitted. This, naturally promotes a number of questions. Does this new treatment cause the lehring or baking out of the lamp to become more critical? Oxidation takes place during this manufacturing phase and an oxypatite layer may be formed, but can the advantage of "stabilization" be lost with improper lehring?

Other aspects beside efficiency and lumen maintenance are also important to the consumer. Currently, color is being studied, so what are the effects of this new treatment on the phosphor's stability colorwise during the life of the lamp? Do temperature extremes during lamp operating cause unsatisfactory lamp performance?

Every engineering advancement opens up a new flood of questions that need answers and it is my hope that the authors will continue their investigation to provide these other important data.

H. C. FROELICH:** The authors describe an interesting method of phosphor treatment prior to lamp manufacture which permits them to obtain higher lumen output and better maintenance than their previous production had given with untreated phosphors. As in the past, the gradual improvements in phosphor preparation and lamp processing, truly evolutionary processes, continue to lead to a gradual improvement of lamp performance. This paper is of interest in that it describes one such possible means.

By way of underlining one of the first statements in this paper, lamp performance is intimately dependent upon the composition and the methods of preparing and applying the phosphors, as well as upon lamp processing. In view of this, it should be emphasized that this particular phosphor treatment represents one, but not the only means leading to improved lamps. It appears to be particularly suitable for all the interdependent details of phosphor preparation and lamp manufacture used in the authors' lamp technology. However, equally good or better performance of both 4- and 8-foot lamps can and has been obtained with phosphors that were not treated as described in this paper, by other improved phosphor and lamp processing techniques which are in use today. This is well known — the footcandle meter

*Champion Lamp Works, Lynn, Mass.
**General Electric Co., Cleveland, Ohio.

tells the story. For this reason it is felt that the phosphor treatment described should not be regarded as a panacea for the production of consistently better lamps.

With reference to the theory of lamp depreciation presented here again, it should be emphasized that this theory is still speculative. So far, no clean physical proof has been given for most of the numerous assumptions made in an attempt to correlate the three additive exponentials of the empirical Butler-Lowry maintenance relation with the phenomena individually ascribed to these terms. For example, it has not been established that the process of gas clean-up *per se* results in a lumen loss which follows an exponential relation approaching zero at 100 hours (residual gases in the gas phase are usually cleaned up in a matter of seconds or minutes); it has not been demonstrated that there is such a thing as a solid phase reaction between the phosphor and the supporting glass wall, at temperatures but slightly higher than room temperature (lamps would then depreciate during shelf life); the photolysis of the phosphors by 1849A radiation is still a matter of debate, with some experimental evidence seemingly supporting it, and some directly disproving it.

In comparing the six constants of the three exponentials for treated *vs* untreated phosphors, the authors consider only the change to the better in the "C" term from 15 to 8 as being significant, and they disregard the change to the worse in the "B" term from 3 to 5 in their discussion. The two changes are of the same order of magnitude and the "B" term in the additive relationship is equally effective in determining the final level of the maintenance curve. In fact, examination of the graphs shows that more than half of the total lumen-hour gain has been realized simply by improved initial, zero-hour efficiency.

There are other points which may be discussed in the light of the theory presented. For example, older work had shown that increasing amounts of antimony oxide progressively improve lamp maintenance with previously used phosphors. This should still hold with the halo-phosphate phosphors, as it should be immaterial what the nature of the substrate is that an effective protective layer protects. It is not clear how the theory fits in to explain the divergent behavior of halo-phosphate lamps. Incidentally, the amount of 1849A radiation absorbed by the antimony oxide layer is relatively small, only about 25 per cent according to Reference 2, hence 75 per cent of the available 1849 radiation still reaches the phosphor to do damage, if any. Also, the change in filling pressure from 3.2 to 1.8 mm argon results only in a rather small percentage gain in 1849A intensity, along with a somewhat smaller gain in 2537A intensity. Hence drastic effects upon lamp maintenance should not be expected on this count.

The authors postulate the formation of a non-fluorescent protective layer of oxyapatite on the phosphor. However, Jenkins et al. (*Journal of Electrochemical Society* 96, 1 (1949)) reported earlier that axyapatites are effectively activated with antimony to give a blue emission. If oxyapatite phosphor can be prepared separately, why should it be non-fluorescent as a surface layer on halophosphate?

The authors' curves show an increase in reflectance of the washed over the untreated phosphors, throughout the ultraviolet range from 2500 to 4000A. Other factors remaining constant, an increase in reflectance amounts to a reduction in absorption. It would be of interest to have a more detailed explanation why, despite their lower 2537A absorption, the treated phosphors give a higher luminous brightness in powder from and in lamps.

In conclusion, and regardless of theoretical interpretations, the authors are to be commended on their practical accomplishment to improve fluorescent lamps by their phosphor treatment. And in the interest of competitive progress it is also good to know that different techniques lead to the same end result.

H. H. Homer, K. H. Butler, M. J. Bergin:* Referring to Mr. Holden's remarks — the details of the phosphor treatment were purposely omitted from the paper since the method of treatment had been described elsewhere, and the authors believed that such an inclusion would be merely repetitious. With regard to the question of possible increasing the sensitivity of the phosphor to adverse processing conditions such as lehring, no differences could be observed between stabilized and unstabilized phosphors. Both were equally affected by improper processing and finally the "stabilization" treatment has not been observed to have any effect on color stability or temperature dependency.

With reference to Dr. Froelich's remarks — the authors have scrupulously avoided any comparative data with lamps of other manufacturers as a matter of principle, not from any sense of inferiority. Much as been said about the fact that the Butler-Lowry theory of lamp depreciation is based upon assumptions of three mechanisms occurring during the life of the lamp. Questions about the validity of these assumptions have been occurring for some little time, but as yet a better explanation has not been offered. In defense of our position it can be stated that we have a considerable collection of data, as yet unpublished, to substantiate the assumptions.

It is true that the authors have apparently laid stress on the changes occurring in the "C" term constants while seemingly ignoring the adverse changes of the "B" term. However, according to the Butler-Lowry theory, the "B" term is effective only to about 1500 hours of life while the "C" term is operating throughout the entire life of the lamp. In other words, the "C" term has five times the effect of the "B" term. In addition it should be pointed out that while 2 and 7 are in the same order of magnitude, a net gain of 5 is certainly significant.

A careful reading of the present paper will show that the authors propose a non-fluorescent deleterious layer of an oxyapatite, which is removed in the "Stabilization" treatment and replaced by a protective layer, not necessarily an oxyapatite. Furthermore, Jenkins et al stress the point that their antimony-activated phosphor is probably an hydroxy-apatite rather than an oxyapatite.

The authors are pleased to learn from Dr. Froelich's comments that others are also concerned with the problem of improving phosphor performance. It would be interesting to know whether the different techniques for phosphor improvement mentioned by him lead to improved maintenance in addition to improved initial lumen output.

*Authors.

A.I.A. File No. 31

INSTALLATION IN PEPPER PIKE, OHIO.

Lighting a Kitchen with a Slanted Ceiling

LIGHTING OBJECTIVE: To provide recommended levels of local and general lighting in a kitchen with a slanted ceiling.

GENERAL INFORMATION: This kitchen is in a kitchen-dining area 15 feet by 20 feet divided approximately in the middle by a hinged workshelf-breakfast-bar. The plastered ceiling slopes from 8 feet at each side of the room up to 11 feet in the center. An 18-inch deep beam runs along the center ridge of the room. The ceiling and walls are painted yellow (75 per cent reflectance). The principal work area is along the outside or window wall in which the sink and range are flanked on either side by four feet of work space. This work space and the breakfast-bar, which also serves as a work counter, are of coral laminated plastic (about 40 per cent reflectance). The counter beneath the wall refrigerator is only 30 inches high and is used principally as a place to set or organize food before putting it away. All upper wall cabinets are of natural mahogany (about 35 per cent reflectance) and all lower cabinets are bluegreen (35 per cent reflectance) matching the wall refrigerator. The floor is of vinyl tile in shades of brown and tan (about 35 per cent reflectance).

INSTALLATION: Because of the slanted ceiling, conventional type ceiling units could not be used in this kitchen. To light the principal working area and also furnish the general lighting in this part of the room, a double row of fluorescent channels and lamps was run above the sink and range and continued as a single row over the counters at either side. As shown in Figs. 2 and 3 this was constructed like a window valance except that the wiring channel was mounted on the

(over)

A.I.A. File No. 31

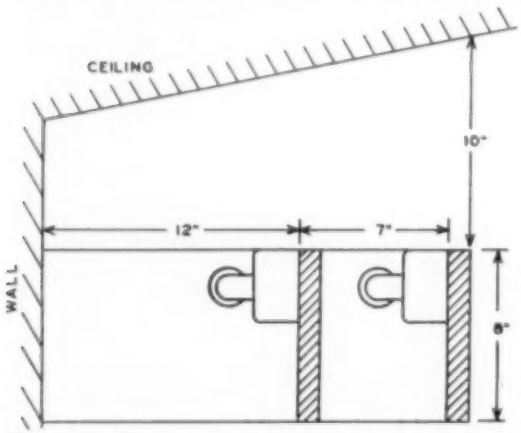


Figure 2. Cross-section of valance over sink and range.

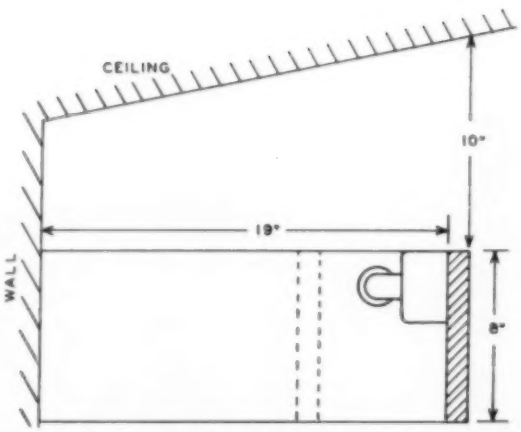


Figure 3. Cross-section of valance over counters at either side of sink and range.

backs of the two faceboards. The outer row of lamps extends from wall to wall and uses one 20-watt T-12 and four 40-watt T-12 fluorescent lamps; the inner row uses two 40-watt T-12 fluorescent lamps. The fluorescent channels are Varco catalog No. 140S and 120S, and all of the fluorescent lamps are deluxe warm white. The valance faceboards are of natural mahogany, matching the upper cupboards.

The work shelf-breakfast-bar is illuminated by three Swivelier catalog No. B-81 "Torpedo" units mounted on 30-inch centers and located directly above the counter. Each unit is equipped with a 150-watt R-40 reflector flood lamp and a No. V louver which rests at the bottom of the unit. The units and louvers are painted yellow to blend in with the ceiling. The louvers are used to provide shielding from wide angles on the kitchen side of the counter while the center beam provides shielding from the dining area.

A shielded wall bracket (Markstone catalog No. KAB-20) using a 20-watt T-12 deluxe warm white fluorescent lamp, is mounted under the wall refrigerator providing light for the casual visual tasks performed there. Since this counter is only 30 inches high and in a passageway between kitchen and dining areas, it is used only as a place to set food and dishes rather than as a work counter.

Illumination measurements taken after over 100 hours of operation are as follows:

center of range, sink area	50 ft-c	work counter, near wall	20 ft-c
outer edge of range, sink	40 ft-c	breakfast bar, kitchen side	40-45 ft-c
work counter, close to sink	35 ft-c	counter under wall refrigerator	25 ft-c

Brightnesses are as follows:

ceiling immediately above valance	150 ft-L
wall immediately above valance	90 ft-L
inner valance faceboard	100 ft-L

NOTE: While the quantity of light at the very ends of the work counters adjoining the sink is somewhat lower than recommended practice, it should be noted that over 75 per cent of principal work counters are lighted to an average of between 40 and 45 footcandles.

Lighting Designer: W. D. Riddle, architect, General Electric Institute, Nela Park, Cleveland, Ohio; builder: Keyes-Treuhaft Co., Inc., 10515 Shaker Boulevard, Cleveland, Ohio.

Lighting data submitted by Rose Coakley, Market Development, General Electric Lamp Division, Nela Park, Cleveland, Ohio, as an illustration of good lighting practice and an aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Elongated Carbon Arc Sources

By STANLEY M. SEGAL

The military, the motion picture industry and the makers of floodlights could use a shaped carbon arc light source. Here is an attempt to break from the conventional round source.

HORIZONTALLY elongated carbon arc sources may lend themselves to military as well as commercial applications. The purpose of this report is to indicate the feasibility of such sources and to engender interest in their development and application.

Late in 1951 the Engineer Research and Development Laboratories assembled a number of various types of intermediate size searchlights for the purpose of field comparisons. The two extremes in size were 10-inch and 24-inch searchlights. At this demonstration a 25mm by 1.5mm mercury capillary arc was operated with an 18-inch reflector. Although the beam candlepower and infrared beam intensity of this capillary searchlight were low in comparison to those of some of the other searchlights demonstrated, a marked enthusiam was evident for the wide horizontal beam spread it exhibited. At that time, the next logical step to take in the field of applied research seemed to be the development of a source with the same general geometric configuration of the mercury capillary but with a higher brightness or at least with a significantly higher infrared intensity per unit area. One of several approaches was the use of the carbon arc. Early in 1952 a positive electrode was cut from solid carbon stock. It was one inch wide and one-eighth-inch high in cross section. It was possible to completely ignite the end with a single carbon cathode and the idea looked promising. Later that year and again in 1953 a cored carbon one inch by one-quarter inch was fashioned and tested. Its operation also looked promising. Following the establishment of a photometric and research laboratory in 1954-1955 a concentrated set of examinations were made in that approach. This report summarizes the results of those examinations.

Carbon electrodes investigated varied in shape and size and the number of combinations of these variations together with the variations in arc length, arc voltage and angles between electrodes became very high. Therefore this presentation was simplified in that the width of all positive electrodes discussed were only those which were identical — 32 millimeters; and all negative electrodes were identical — the eight millimeter, high intensity negative searchlight electrode. All positive electrodes were cut from the same type carbon stock and all rare earth core materials used were obtained from the cores of discarded remnants of used positive electrodes of high intensity searchlights.

The power used could have been either direct current or alternating current. There were advantages and disadvantages inherent to either system. Very little time was expended on the a-c approach; however, feasibility was demonstrated very quickly and a contract let in 1953, for the development of an a-c lamp.[1] The present discussion in its preparation was confined to the d-c approach.

Because the arcs described were considered somewhat of an innovation a large number of illustrations were prepared in order to facilitate a visual conception by those workers in the field who might be interested in contributing to further investigations or development. These figures are grouped as follows:

1-4: Experimental lamp.

5-9: Solid positive electrodes with rectangular cross sections.

10-13: Solid positive electrodes with oval cross sections.

14-18: Solid positive electrodes with rectangular cross sections, 6 millimeters high.

19-29: Cored positive electrodes with rectangular cross sections 6 millimeters high.

30: The mercury capillary.

The apparatus consisted of the lamp mechanism and photometric equipment. The lamp mechanism was modified to provide a simple set of brass jaws for holding the uncooled positive electrodes, Fig. 1, and a spring loaded set of water cooled jaws, Figs. 2 and 3. The walls of the water cooled jaws were

AUTHOR: Research and Photometric Section, Night Vision Equipment Branch, Electrical Engineering Dept., Engineer Research and Development Laboratories, Fort Belvoir, Va.

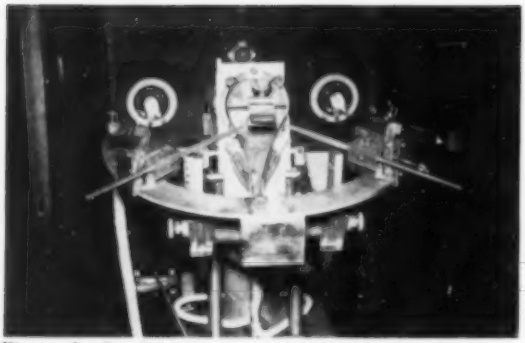


Figure 1. Dual negative experimental carbon arc lamp with uncooled jaws holding cored positive electrode with rectangular cross section.

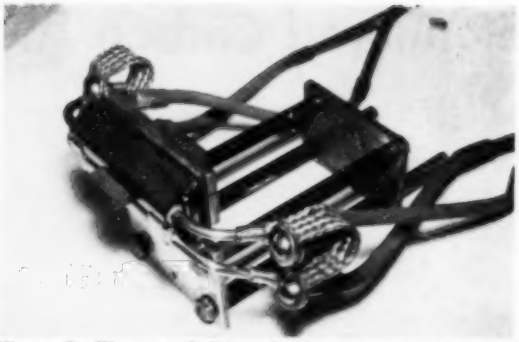


Figure 2. Water cooled jaws holding new positive cored electrode.

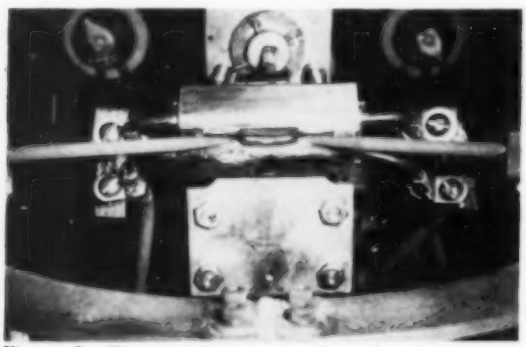


Figure 3. Water cooled positive jaws showing damage due to flashback.

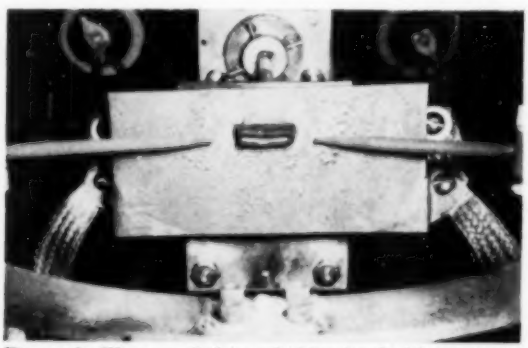


Figure 4. Water cooled jaws hidden by flashback shield.

Figure 5. End view of 32mm x 3mm electrode.

Figure 6. Solid 3mm high positive electrode operating with a single negative electrode.

Figure 7. Solid 3mm high electrode operating with dual negative electrodes showing a combined single anode approach.

Figure 8. Solid 3mm high electrode operating with dual negative electrodes showing separate anode approaches.

Figure 9. Top view of 3mm high solid electrode showing deep concave curves cut by a single electrode operation after 30 seconds, left, and after two minutes, right.

Figure 10. Solid electrode with oval cross section.

made of $\frac{1}{16}$-inch stainless steel with silver at the electrode contacting surface. Thin sheet metal was used to effect rapid cooling but presented the danger of easy flashback damage since the electrodes were operated at a protrusion of $\frac{3}{8}$-inch. The first strike produced three small leaks due to flashback. A replaceable $\frac{1}{16}$-inch copper shield, Fig. 4, was provided to protect the jaws and no further flashback damage was experienced. The shield was set $\frac{1}{16}$-inch in front of the jaws and was supported solely at the two end current connections of the jaws. The reasoning followed was that the flashback current would be conducted around the jaws. Protrusion in front of the shield then became $\frac{1}{4}$-inch. The water jaws and protective shield were larger than necessary and the materials used were not optimum. The material and dimension selections were merely made on a basis of convenience since they did not enter into the purpose of the experiments. Variable speed automatic feeding mechanism was provided for the positive electrode.

Two negative electrode holders were mounted on a semicircular ring. The ring was marked off in degrees and allowed either negative jaw to be adjusted zero to 90 degrees. The ring was split into two halves at its center and insulation provided between them. Each half was then connected to a separate variable water cooled nichrome ballast. The negative holders were provided with spring loaded self retracting strikers. The complete ring assembly was then mounted on a second set of rings marked off in degrees from zero to 90 thus permitting simultaneous variations in vertical as well as horizontal angles between the negative electrodes and the positive electrode.

The photometric equipment consisted of calibrated visible and infrared sensitive elements, imaging devices, a synchronized scanning board-recorder combination, and associated amplifiers. This equipment and the procedure, which has become fairly well standardized among a number of laboratories, were described in a previous paper.[2] However, two pertinent details were stop sizes and the spectral responses. The diameters of the circular stops used with all radiation sensitive scan elements were such that the area integration at any instant during the determination of the distribution of brightness or infrared intensity per unit area across the source was a circle 0.018 inch in diameter. The brightness measuring element was corrected to match eye sensitivity and the infrared element was an RMA-designated S-1 response photoemissive surface used in conjunction with the RETMA Standard IR filter (Corning No. 2540, 2.60mm, Melt 1613).

The operation of these novel sources was approached as simply as possible and step by step complications were added as they became necessary. The sequence was as follows: rectangular cross section solid positives, 32mm x 3 mm, with single negative; the same with dual negatives; oval cross section solid positives, 32mm x 6mm with single negative; rectangular cross section solid positive, 32mm x 6mm, with single negative; the same with dual negatives; and finally with water cooling added.

The first selection of a 32mm x 3mm solid positive was based on the performance of the mercury capillary, Fig. 30, a very interesting and fine source for certain applications but failing in brightness and spectral characteristics for other applications. The capillary source, 25.5mm x 1.5mm, also exhibited too narrow a vertical spread at zero azimuth for certain applications when operated with an 18-inch reflector. Therefore the height was doubled and the length increased by 25 per cent, Fig. 5. Objectionable features were a narrowing of height due to evaporation before ignition and the development of a deep concave crater due to more rapid burning of the central area, Fig. 6 and 9. The latter difficulty was overcome by using dual negatives, Fig. 8. Dual negatives were objectionable at first because individual ballasts were required and because of difficulty in striking. A simultaneous strike drew too much current and with successive strikes the second strike extinguished the first arc by a momentary drain on the total current and the sudden unbalance in magnetic fields. Also, even though both negatives would be conducting, there was a tendency for the arc of one negative to combine with the arc of the other before approaching the anode as illustrated in Fig. 7. The foregoing difficulties were later overcome by changing the arc parameters; but before this was done, a retreat was made to the single negative and an anode with oval cross section.

The oval cross section was tried in order to counteract the rapid central evaporation when using the single negative, Fig. 10-13. Only marginal improvement was found (compare Fig. 9 and 13).

A return was made to dual negatives using a solid anode 32mm x 6mm in cross section. At first it was believed that arc foot point guidance in the form of anode holes or ground carbon cores would provide a quieter arc, Figs. 14-16; but later this was found to be unnecessary, Fig. 17. However, this was a happy misconception because it accidentally disclosed a phenomenon which may prove of interest to future investigators. The neutral cores, or holes, generally showed up as dark spots in the brightness distribution measurements; how-

Figure 11. Oval electrode after 30 seconds of operation with a single negative electrode.

Figure 12. Oval electrode after 4 minutes of operation with a single negative, showing fifteen per cent loss in horizontal elongation due to lateral "ears."

Figure 13. Top view of oval electrode showing lateral "ears" after four minutes of single negative operation.

Figure 14. End view of 6mm high solid electrode showing holes bored for arc stability.

Figure 15. 6mm solid electrode operating with dual negatives.

Figure 16. 6mm solid electrode operating with dual negatives after stabilizing holes had been packed with pulverized graphite.

Figure 17. 6mm solid electrode with no stabilizing holes operating with dual negatives.

Figure 18. Top view of 6mm solid electrode, showing convex curve on left resulting from five minutes of operation with dual negatives set at 80 degree angles.

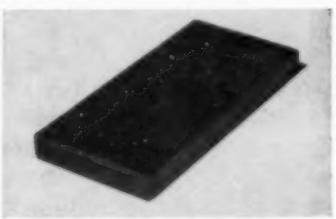


Figure 19. High intensity 32mm x 6mm electrode cored with rare earth materials.

ever, with the proper arc parameters (arc length, voltage, current, and electrode angle) the arc became more silent and the dark spots became more brilliant than the surrounding carbon. When the brightness of these spots was measured and found to be almost twice the value expected for solid carbon, it was surmised that cavity radiation was responsible. Zero degrees seemed to be the optimum vertical angle for the negative electrodes while concave, straight, or convex (Fig. 18) burning ends could be maintained by operating with horizontal angles of 60 degrees, 70 degrees and 80 degress, respectively. The angular values indicated are angles in a horizontal plane made between the negative carbon and the longitudinal axis of the positive carbon.

High intensity cored carbons, 32mm x 6mm, were made by hand, Fig. 19. Slots were made in solid blanks and carefully packed with rare earth materials which had been salvaged from old standard H. I. searchlight carbon remnants and made into a mastic by crumbling into a powder and adding water. While these were the most tedious to fabricate they were the easiest to operate. Single negative arcs performed as expected, Figs. 20-21. It was not necessary to advance both negatives in the dual negative set up. When one negative was struck the tail flame immediately reached the second negative and automatically created a dual strike with separate anode approaches. Variations are illustrated in Figs. 22-29.

Photometric measurements consisted solely of distribution determinations of intensity per unit area in the visible and the near infrared. Tungsten ribbon operating at a color temperature of 2870 degrees K, Figs. 31 and 37, was used as a measuring

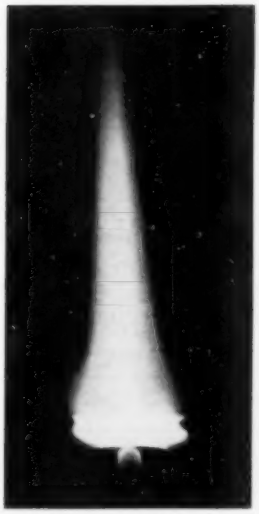


Figure 20. Cored high intensity electrode operating with a single negative showing 35 per cent decrease in horizontal elongation due to lateral "ears."

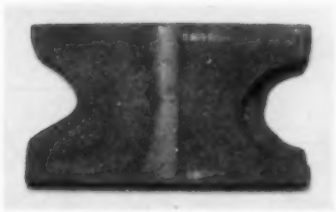


Figure 21. Top view of cored high intensity electrode showing deep concave craters cut by a single negative operation after 30 seconds on the left and after one minute on the right.

Figure 22. End view of cored high intensity electrode before operation.

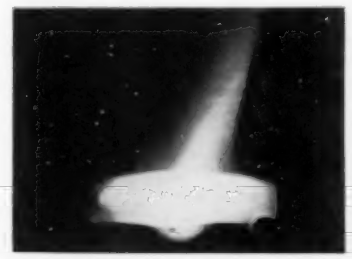


Figure 23. Cored high intensity electrode during operation with dual negatives set at too sharp an angle creating a concave source resulting in loss of horizontal elongation.

Figure 24. Negatives set at 80 degree angles creating convex source with resulting loss in brightness.

Figure 25. Negative set at 70 degree angles creating straight source.

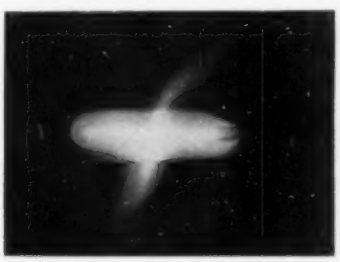


Figure 26. Faster photographic exposure to "cut down" brightness of crater.

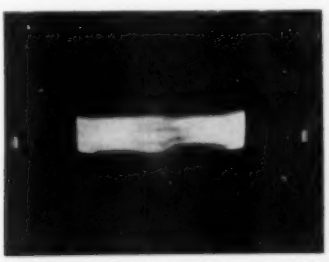


Figure 27. Negatives set at 85 degrees, showing reduction in brightness at center of convex light source.

Figure 28. High intensity straight source after six minutes of operation showing carbon shell evaporation.

Figure 29. Top view of cored electrode after six minutes of operation showing evaporated shell to the right but exhibiting no significant curve on end.

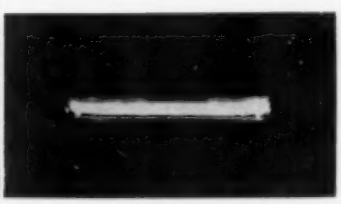


Figure 30. Mercury capillary in operation.

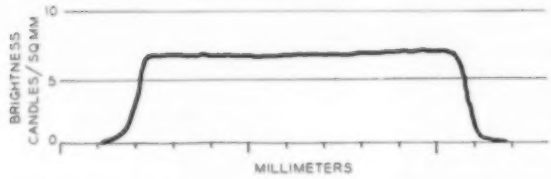


Figure 31. Brightness scan across tungsten ribbon operating at a color temperature of 2870 K.

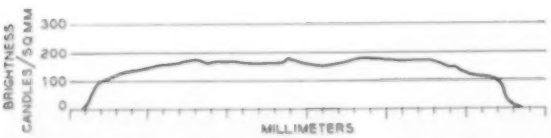


Figure 33. Longitudinal brightness scan of 32mm x 6mm solid positive with dual negatives carrying a total current of 140 amperes.

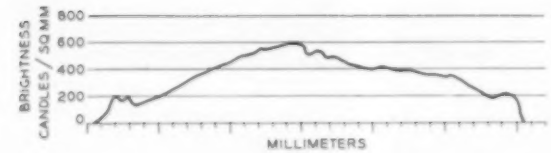


Figure 35. Longitudinal brightness scan of H.I. positive 32mm x 6mm electrode operating at a total current of 140 amperes with dual negatives.

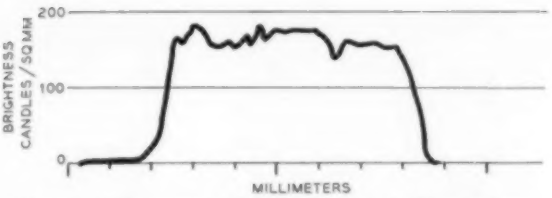


Figure 32. Transverse brightness scan of 32mm x 6mm solid positive operating with dual negatives with total current of 140 amperes.

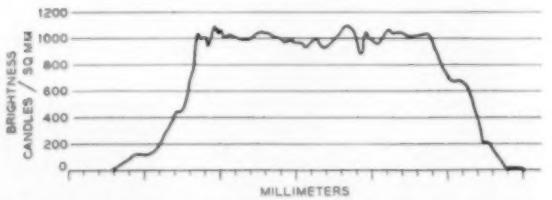


Figure 34. Longitudinal brightness scan of water cooled high intensity 32mm x 6mm cored positive electrode operating at 260 amperes with a single negative electrode (see Fig. 20).

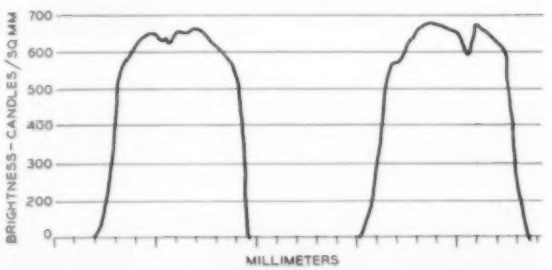


Figure 36. Two transverse brightness scans taken 30 seconds apart at the same position eight millimeters in from the left edge; the left scan was taken with both negatives firing with a total current of 240 amperes; the right scan was taken with the right negative removed without extinguishing the arc which dropped the total current to 120 amperes.

stick. Brightness of solid carbon approximated 180 candles/sq mm, Figs. 32-33, and did not increase when loaded with higher current except in the case of cavities mentioned earlier. Thus solid carbon was 25 times brighter than tungsten ribbon operating at a color temperature of 2870 degrees K, 14 times brighter than tungsten wire operating at a color temperature of 3100 degrees K, nine times brighter than a tungsten wire operating at a color temperature of 3300 degrees K and better than three times brighter than tungsten wire melting at a color temperature of 3817 degrees K.

The water cooled H. I. 32mm x 6mm cored positive exhibited a brightness of 1000 candle/sq mm over a 16mm longitudinal scan when operated at 240 amperes with a single negative, Figs. 20 and 34. The flat distribution of Fig. 34 is characteristic of infrared intensity per unit area distribution but it is not characteristic of brightness distribution. The flat top, sharp cut off and shortened horizontal span in this instance was due to the deep concave shape and shadowing by lateral "ears," Fig. 21. The brightness distribution illustrated in Fig. 35, was obtained with a H. I. positive and dual nega-

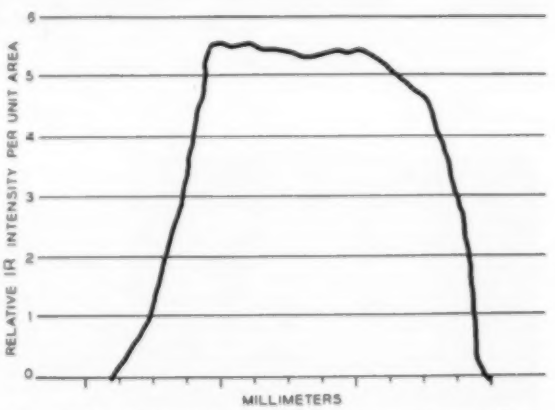


Figure 37. Infrared intensity per unit area scan taken across a tungsten ribbon filament operating at a color temperatue of 2870 K; the sensitive element was an RMA designated S-1 response with an RETMA standard IR filter (Corning No. 2540, 2.60mm, Melt 1613).

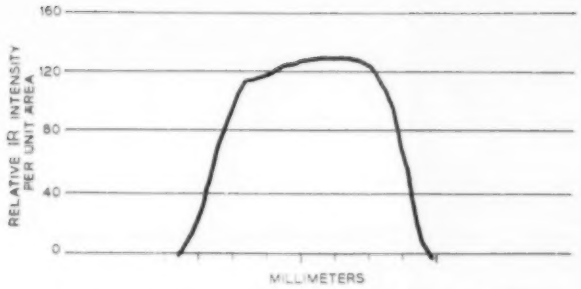


Figure 38. Transverse infrared scan across a 32mm x 6mm solid positive operating with dual negatives and a total current of 120 amperes.

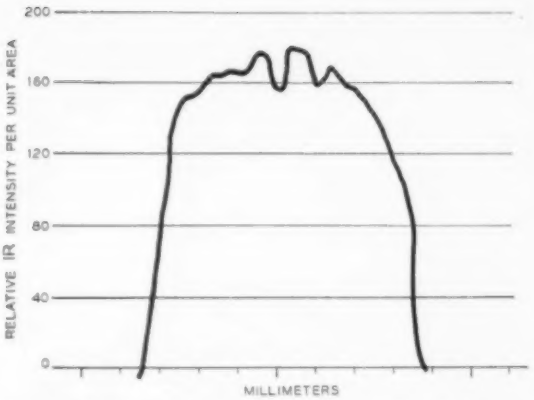


Figure 39. Transverse infrared scan of H.I. 32mm x 6mm cored positive operating with dual negatives, total current 200 amperes.

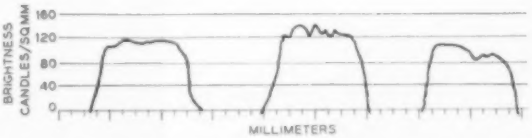


Figure 40. Transverse infrared scans across H.I. 32mm x 6mm cored positive operating with dual negatives and a total current of 160 amperes; the left scan was taken 5mm from the right edge and the center scan was taken across the midpoint, illustrating the "flat top" distribution of infrared intensity per unit area.

tives operating at 140 amperes. A flat brightness distribution was possible as illustrated in Fig. 25, by proper electrode angle adjustment and even central dip can be obtained by additional angle adjustment as illustrated in Fig. 27. The 32mm x 6mm H. I. electrode built could not be fully loaded because of the 260-ampere limitation of the equipment used. This was realized from the experiment illustrated in Fig. 36, where it was seen that a 240-ampere dual electrode arc was, in effect, two adjoining 120-ampere arcs.

The infrared intensity per unit area of the solid carbon electrodes was approximately 23 times greater than that of the tungsten ribbon operating at a color temperature of 2870 degrees K, Figs. 37-38. Although the H. I. carbon was 33 times greater, Fig. 39, a disproportionately higher power was required and a disproportionate increase in brightness was observed which would present filter problems to the application engineer. It was suspected that the greatest contribution to the infrared came from the carbon rather than the rare earth core material and the IR increase may be due to carbon particles trapped in the high temperature, high pressure crater characteristic of the high intensity arc anode. However, another approach toward accentuating the infrared characteristics of carbon arcs is the inclusion of special core material, such as strontium, in the high intensity positive carbon.[3]

The power consumed by the arcs described in this paper varied over a wide range. The lowest power necessary to completely ignite the end of a 32 mm wide anode was 1.8 kw while the highest power employed was 20.8 kw.

The investigation described in this paper was preliminary in nature. The prime goal was a demonstration of the feasibility of a carbon arc with a substantial horizontal elongation. Much more research and engineering will be necessary before an efficient horizontally elongated carbon arc searchlight becomes a reality. Meanwhile the author believes that whether other workers in the field develop even longer cross sections for floodlighting applications or shorter rectangular cross sections to fit the motion picture frame, the trend for the future should be toward the condition where the application engineer will be able to meet the specification regardless of the geometry specified.

The author takes great pleasure in acknowledging the valuable encouragement of Mr. Benjamin Goldberg and Dr. Robert S. Wiseman, as well as the ingenious electrode fabrications and lamp modifications of Mr. John A. Schmidtlein, the accurate photometry performed by Mr. Joseph S. Bunor and the highly interpretive and scientific photography of Mr. Eugene T. Chapman.

References

1. Latil, J. P.: "A New Searchlight Carbon Arc Lamp," ILLUMINATING ENGINEERING, Vol. L, No. 8 (August 1955).
2. Segal, Stanley M.: "A Study of High Intensity Light Sources," ILLUMINATING ENGINEERING, Vol. L, No. 5 (May 1955).
3. Catalog Section A-4300, "Radiation Characteristics," published by the National Carbon Company, Incorporated, Unit of Union Carbide and Carbon Corporation.

Fiftieth Anniversary Luncheon

General view of the 50th Anniversary Luncheon held at the Astor Hotel on January 11.

Seven Past-Presidents of I.E.S. attended the Anniversary Luncheon at the Sheraton-Astor Hotel, New York, the hotel being the birthplace of the Society on January 10, 1906. Shown here with current President, Robert F. Hartenstein they are: left to right, seated: Dr. George S. Crampton, Dr. Ward Harrison, William F. Little and Dr. Joseph W. Barker; standing: Lee Tayler, Mr. Hartenstein, Duncan M. Jones and Dr. Samuel G. Hibben.

Drawings of the bronze plaque to be installed soon in the lobby of the Sheraton-Astor are presented to Ralph H. Freeman, left, New York regional manager of the Sheraton Hotels, by President Robert F. Hartenstein, center, and Dr. Samuel G. Hibben, right, Past-President and Chairman of the I.E.S. Historical Committee.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Fiftieth Anniversary of Society's Founding Celebrated at Astor Hotel, New York City

Some 30 to 35 Sections and Chapters of I.E.S. held commemorative meetings during January, in honor of the Society's fiftieth anniversary. As many more are scheduled during the rest of the year. Accounts of these, with pictures, will no doubt be available for later issues of Telecast.

Nationally, however, the Society's birthday was observed with what was almost a re-enactment of the meeting fifty years ago, at which I.E.S. was founded (on January 10, 1906). On the same site, the Astor Hotel in New York City, a special commemorative luncheon was held January 11. Twenty-nine people attended, including seven distinguished past presidents of I.E.S.

Highlight of the occasion was the presentation of drawings of a bronze plaque to the Astor management. The plaque, noting that the Illuminating Engineering Society was founded at a dinner meeting there, will later be installed permanently at the Astor, possibly in the lobby. R. F. Hartenstein, President of I.E.S., presented the drawing, which was accepted by Mr. Ralph H. Freeman, New York Regional Manager of the Sheraton Hotels, in behalf of the Astor. Details of the plaque, and later on its production, have been under the direction of the I.E.S. Historical Committee, and particularly its chairman, S. G. Hibben.

Principal speakers at the commemorative luncheon were Mr. Hartenstein, President, and Mr. Hibben, Chairman of the Historical Committee. Mr. Hartenstein reviewed the circumstances of the founding of the Society, following which he presented the plaque facsimile to Mr. Freeman, and also read to those present, some 50 congratulatory messages, telegrams and cards. Messages were received from all of the living Past-Presidents who were unable to attend, several Members Emeritus including two Charter Members of I.E.S., numerous Sections and Chapters, and from officers and representatives of many of the Society's Sustaining Members. Indianapolis Chapter had air-shipped a large segment of its own anniversary cake, which was shared by all at the luncheon.

In addressing the luncheon group as Chairman of the Historical Committee, Mr. Hibben drew much of his interesting account of early lighting developments from his own recollections. He noted, as an example, that the lighting of the Astor Hotel in 1905 was the first Planned Lighting Job in the United States, in that it was the first complete relighting installation done to a studied lighting plan.

Each of the seven Past-Presidents at the luncheon recalled for those present some interesting highlight of his administrative year. For many of them, the occasion was a happy reunion with old friends, as well as a birthday celebration for the Society.

Since one of the most interesting items of the account of the Society's First Year (January I.E., p. 145) was the verbatim quote of L. B. Marks' letter inviting the founders to the Astor, it seems appropriate to place into the record here, the letter inviting all concerned to a luncheon to commemorate that event, fifty years later:

To: Officers of the Society
Past Presidents
Golden Anniversary Committee
Officers of the Northeastern and East Central Region
From: A. D. Hinckley,
Executive Secretary
Subject: I.E.S. Golden Anniversary Luncheon
12 Noon, Wednesday,
January 11, 1956
Hotel Astor, Times Square,
New York, N. Y.

President Hartenstein has asked that we send you this memo, inviting you to be present for this luncheon which will publicly start the Anniversary Celebration. The luncheon program will include the presentation of a facsimile of the Plaque proposed to mark the birth place of the Society at the Hotel Astor.
Please indicate whether or not you can plan to be present on the return postcard. The cost for the luncheon will be about $5.00 to each in attendance.

The list of the 25 men who attended the original meeting in 1906 is not now available. For the record, however, attending the Commemorative Luncheon in 1956 were: Five National Officers: R. F. Hartenstein, K. M. Reid, M. N. Waterman, G. J. Taylor, J. S. Schuchert; Seven Past Presidents: Ward Harrison, W. F. Little, S. G. Hibben, L. E. Tayler, J. B. Barker, D. M. Jones, G. S. Crampton; Eight Members and Officers of the New York Section and Northeastern Region: R. D. Babcock, Secretary, Connecticut Section; G. W. Beals, Chairman, Procedures and Policies Committee; Louis Goren, Chairman, New York Section; C. C. Keller; H. L. Logan; C. W. McCormick, Regional Vice-President; G. G. Rae, Vice-Chairman, New York Section; D. J. O'Neill; G. F. Dean, Chairman, Constitution and By-Laws Committee; F. C. Winkler, Chairman, Advance Planning; Four Senior Staff: A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Editor; C. E. Ellis, Advertising Manager; and three Press Representatives.

I.E.S. National Technical Conferences

1956 — September 17-21 — Hotel Statler, Boston, Massachusetts

1957 — September 9-13 — Biltmore Hotel, Atlanta, Georgia

1958 — August 17-22 — Royal York Hotel, Toronto, Ontario

1959 — September 7-11 — San Francisco, California

How YOU Can Sell SUSTAINING MEMBERSHIPS

Sustaining Member News

Take a bow, everybody! We have the Council Executive Committee gasping at the results of our S-M work. The first meeting they've he'd since our campaign began was at I.E.S. headquarters on January 12, so our first batch of new Sustaining Members, and increased dues from older ones, was presented for their o.k. These five top officers, with years of experience in I.E.S. work, just couldn't get over it. Fourteen brand new members, plus 35 increases in S-M dues — and substantial increases! It all added up to $7,525.00 at this one meeting. And that's only the beginning.

As you know, in line with action taken at the October Council meeting, two-thirds of this is earmarked for Research (Minute No. 8, October 13, 1955). As a matter of fact, if the contributor wants it that way, *all* of the increase (or new dues) could be channeled to research work. But in the absence of any instructions along this line, two-thirds is automatically budgeted to Research. This is certainly all to the good. By far the most important need for a larger S-M income is more basic research. It is vital to our industry. Up to now, the Society has only been able to squeeze out about $5,000 a year for research work, and even that was only possible by sacrificing other desirable projects. Twenty-five thousand a year for research alone, would be more like it, and more would be even better.

In addition to research in basic fundamentals of illumination, there's a list as long as your arm of things I.E.S. needs to do, when it can afford it. These projects are loaded with benefits to all of us in lighting. What are they? Well, it might take this whole column to list them all, but to name a few:

Allowance in the Section and Chapter budget for increased local service to members.
Underwrite Regional Conferences.
Regional Vice-Presidents' Travel expenses.
I.E.S. educational films on lighting principles.
Annual report in attractive brochure, mailed to all members, and Sustaining Members.
Annual Membership Roster, mailed to all members.
Fund for support of technical activities of the Technical Committees, Forums, and lighting competitions.
Greater prize money for "My Most Interesting Lighting Job" contest.
Full-scale public relations program.

There are more — plenty more. But support of even one of the above would pay off in benefits to any Sustaining Member, or potential Sustaining Member. This year's S-M Committee is out to get these projects going, and others as well. To do this, they must bring the I.E.S. story to the attention of the companies who benefit from I.E.S. work. If any member would like to join this team, he is certainly welcome. See December I.E. page 8A for a description of the six divisions of Sustaining Member organization. Pick whichever you can do the most good in, and write to its chairman, or write directly to: I.E.S. Sustaining Membership Committee, 2615 Washington Blvd., St. Louis 3, Missouri.

(Continued on page 13A)

Palmetto Chapter Works for Illumination Course at Clemson

Six professors from the Architectural and Electrical Engineering Departments of Clemson College and Roy A. Palmer and R. Neal Campbell of the Palmetto Chapter, I.E.S., were the leaders in a round table discussion on how the Chapter can help in establishing a course in illumination at Clemson College. About 50 members of the Chapter attended.

Chicago Lighting Institute Announces Headquarters Move

The Chicago Lighting Institute is moving its headquarters to 140 South Dearborn St., in the Marquette Building, where it will occupy space on the second floor. Architects, Shaw, Metz and Dolio have been commissioned to design the new Institute.

Until the new quarters are completed the Institute is occupying temporary space in the building and is continuing with its evening courses and daytime clinics.

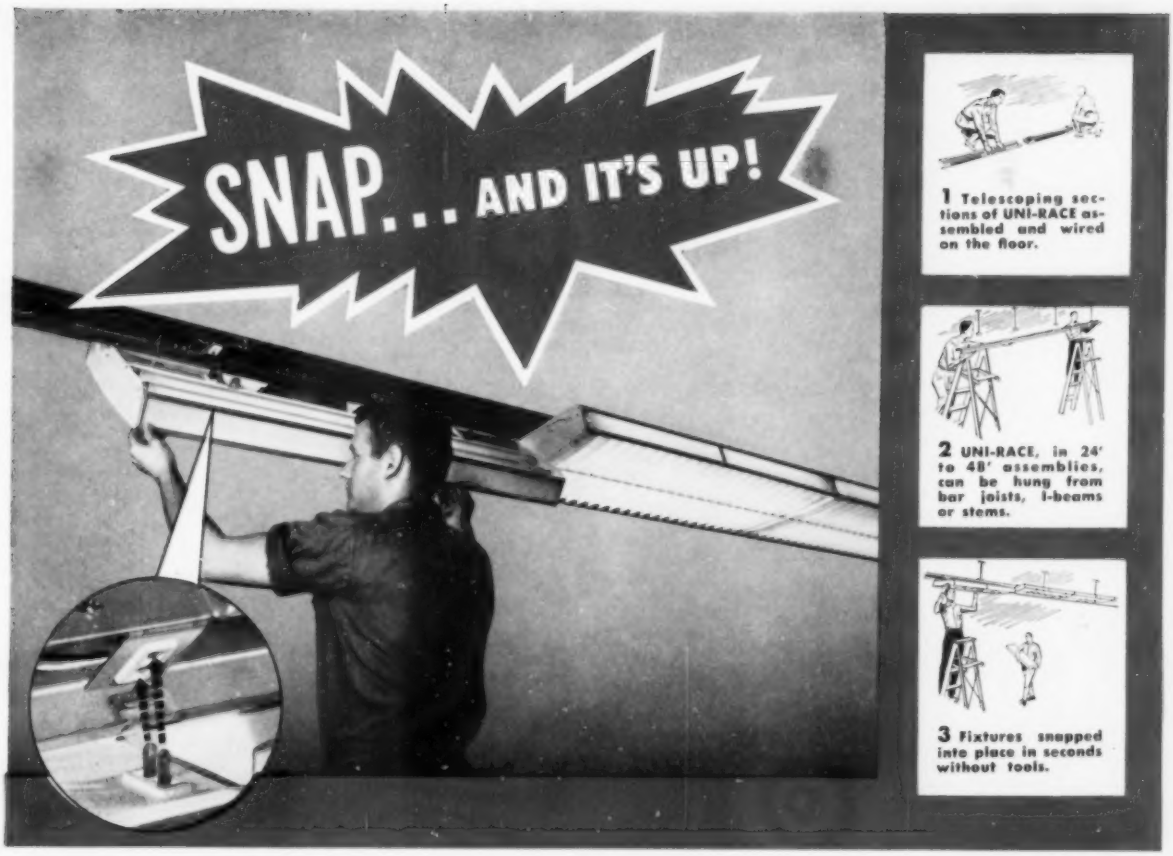
Industrial Lighting Clinic

The last clinic prior to this move was that on Industrial Lighting which was held at the former headquarters at 37 South Wabash Ave. The program for this clinic was as follows:

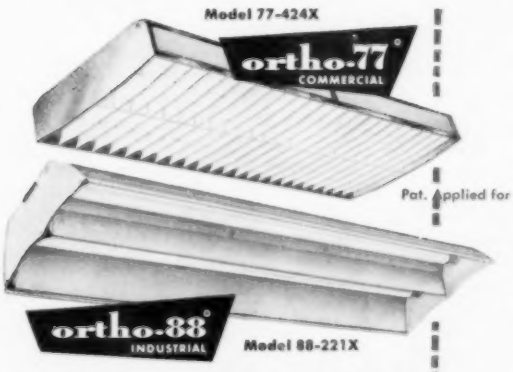
Morning

Introductory Remarks — C. N. Carlson, Commercial Engineer, Public Service Co., Northbrook, Ill.
Lighting for Plant Parking Areas, Plant Protection and Floodlighting Front of Buildings — Elden H. Witte, Illuminating Engineer, Benjamin Electric Mfg. Co., Des Plaines, Ill.
Lighting for Executive Offices, General Offices and Company Cafeteria — Gerald Marks, District Lighting Engineer, Electro Silv-A-King Corp., Chicago, Ill.
Lighting High Ceiling Areas with Incandescent Lamps, Mercury Vapor Lamps, 800-1000 ma Fluorescent Lamps — D. R. Phillips, Industrial Lighting Specialist, General Electric Co., Cleveland, Ohio.

AMONG those taking part in discussions aimed at the offering of a course in illuminating engineering at Clemson College are: left to right, Professor Harlan E. McClure of the architectural department; Neal Campbell, Secretary-Treasurer of the Palmetto Chapter; Glen Rice, Chapter Chairman; Roy Palmer, Fellow of I.E.S.; and Professor Walter Lee Ball of the electrical engineering department.


SNAP... AND IT'S UP!
1 Telescoping sections of UNI-RACE assembled and wired on the floor.
2 UNI-RACE, in 24' to 48' assemblies, can be hung from bar joists, I-beams or stems.
3 Fixtures snapped into place in seconds without tools.

HERE'S BETTER LIGHTING AT HALF THE COST



FEATURES THAT DEFY COMPARISON

- **ON-JOB POWER SOURCE** Before fixtures are installed, receptacles in UNI-RACE provide power source for tools and temporary lighting.
- **NO FIXTURE STORAGE** Fixtures need not be delivered until premises are painted. The units can then be snapped into place—clean and factory fresh.
- **VARIABLE SPACING** Fixtures can be mounted in continuous rows or at intervals of 4, 8, 12 or more feet—added, removed or respaced at any time.

The Gibson ORTHO Fixture is a completely new concept in commercial and industrial lighting design. The exclusive UNI-RACE, shipped separately from the fixtures, provides straight alignment, exact fixture spacing and a fixed power source (receptacle) for each fixture. It banishes those pesky aligning problems and eliminates all electrical work on the fixture itself—just take the units as they come from the box and snap into place at any desired interval of 4′ or 8′ on the UNI-RACE.

All of which adds up to a 50-percent saving in labor and material—often more—unheard of flexibility to the user, and gives you a better-looking, higher-quality job.

There are many other advantages you ought to know about. Drop us a line today, we'll gladly send you complete information about the remarkable new ORTHO-77 and 88 for commercial and industrial applications.

Gibson LIGHTING

GIBSON Manufacturing Co.

Prudential's Minneapolis Headquarters

FUNCTIONALLY BEAUTIFUL in concept, in design

and in **LIGHTING** by **GARCY**

Minneapolis regional headquarters building
Prudential Insurance Co. of America

Architects and Engineers: MAGNEY-TUSLER & SETTER
Electrical contractors: Electric Repair & Construction Co
Distributor: Graybar Electric Co., Inc.

If working can ever be considered a pleasure, it must be enjoyable for employees at Prudential's new regional headquarters in Minneapolis. Everything . . . beginning with selection of a building site at the edge of a city park . . . everything has been thought of to make the employee's working day pleasant. Contributing much to employee comfort is high-level, low-brightness, shadow-free lighting . . . by Garcy.

The Prudential is Garcy Lighting throughout. Acres of offices are lighted by more than five thousand Garcy 4-foot troffers, equipped with low-brightness lenses. Many other manufacturers make troffers, but few are equipped to handle complete lighting contracts for a building of the Prudential's size and scope.

Investigate Garcy fixtures . . . engineered for highest efficiency . . . precisely manufactured for fast installation in any kind of ceiling . . . designed for quick, easy cleaning and relamping.

GARCY *Send for Catalog L-110*

Quality *by Design*

Garden City Plating & Mfg. Co., 1760 N. Ashland Ave., Chicago 22, Ill. / In Canada: Garcy Co. of Canada, Ltd., 191 Niagara St., Toronto

(*Continued from page* 10A)

Lighting General Assembly Areas Including the Machine Shop and Assembly Tables — T. E. Mikita, District Lighting Engineer, Sylvania Electric Products, Inc., Melrose Park, Ill.

Afternoon

Chairman—B. J. Martin, Editor and Publisher, *Electrified Industry*, Chicago, Ill.

Inspection Lighting Techniques (Edge Lighting, Polarized Light and other methods) — James C. Weeks, Illuminating Engineer, Westinghouse Electric Corp., Chicago, Ill.

Lighting for Hazardous Locations, Including Discussion of Explosion Proof and Dust Tight Equipment; also Lighting of Spray Booths — John Crocker, Lighting Engineer, Pyle National Co., Chicago, Ill.

Lighting the Warehouse, Shipping Room, Dock and Platform Areas — Stanley Sharman, Manager of Lighting Sales, Graybar Electric Co., Chicago, Ill.

Maintaining the Efficiency of the Lighting System — Thaddeus D. Cassidy, Electrical Engineer, Crane Co., Chicago, Ill.

Discussion Period.

Eric H. Church, Operations Manager, Lighting Products Inc., was Chairman of the Program Committee for the Clinic.

Certified Lighting Program Underway in Los Angeles

Los Angeles entered the list of areas with Certified Lighting Programs on January 18, when the first session of the training course was held. The first series of classes will be conducted as a pilot course, and registration has been limited to 40.

Sponsoring organizations are the Certified Lighting Association, with Roy Kreyser as Coordinating Director, in cooperation with the Los Angeles City Schools and the Electric League of Los Angeles, Commercial-Industrial Lighting Division.

The seven weekly sessions in the course are as follows:

January 18 — The Language of Lighting — R. E. Bevan, Sylvania Electric Products Inc.

January 25 — Lighting Design — E. R. Balogh, Sunbeam Lighting Co.

February 1 — Lamps and the Job They Do — J. R. Jones, Westinghouse Electric Corp.

February 8 — Lighting for Merchandising in a Modern Store — Ben Seid and D. A. Romanoff, Department of Water and Power, Los Angeles.

February 15 — Office Lighting — T. H. Shepherd, Department of Water and Power, Los Angeles.

February 21 — Lighting Industrial Interiors — R. S. Clubley, General Electric Co.

February 29 — Exterior Lighting — William Shalda, Shalda Manufacturing Co.

With the cooperation of the City School system, the sessions are being held at the Board of Education building, using the facilities of the Adult Education program.

Committee chairmen, in addition to Mr. Kreyser are T. H. Shepherd, Education; Harold Thrane, Attendance; L. A. Hobbs, Financial; Glen Logan and Warren Penn, Promotional; and Mr. Kreyser, Certification.

(*Continued on page* 17A)

LIGHTING CALENDAR

Society Events

April 4, 1956 — I.E.S. Council Meeting, Thomas Jefferson Hotel, Birmingham, Ala.

April 5-7, 1956—Southern Regional Conference, Thomas Jefferson Hotel, Birmingham, Ala.

April 8-10, 1956 — Southwestern Regional Conference, Hilton Hotel, Fort Worth, Texas.

April 11-13, 1956 — South Pacific Coast Regional Conference, Mark Hopkins Hotel, San Francisco, Calif.

April 19-21, 1956 — Pacific Northwest Regional Conference, Davenport Hotel, Spokane, Wash.

April 26-28, 1956—Inter Mountain Regional Conference, Utah Hotel, Salt Lake City, Utah.

May 7-8, 1956—Great Lakes Regional Conference, Commodore Perry Hotel, Toledo, Ohio.

May 10-11, 1956—Midwestern Regional Conference, Severin Hotel, Indianapolis, Indiana.

May 17-18, 1956 — Canadian Regional Conference, Chateau Frontenac, Quebec, Canada.

May 24-25, 1956 — East Central Regional Conference, Shoreham Hotel, Washington, D. C.

September 17-21, 1956 — Illuminating Engineering Society, National Technical Conference, Hotel Statler, Boston, Mass.

September 9-13, 1957 — Illuminating Engineering Society, National Technical Conference, Biltmore Hotel, Atlanta, Ga.

Industry Events

February 23-24, 1956—12th Annual National Adequate Wiring Conference, LaSalle Hotel, Chicago, Ill.

February 26-29, 1956 — National Electric Sign Association, Annual Convention, Jefferson Hotel, St. Louis, Mo.

March 12-16, 1956 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

April 29 - May 4, 1956 — Society of Motion Picture and Television Engineers, Hotel Statler, New York, N. Y.

May 19-20, 1956—International Home Building Exposition, New York Coliseum, New York, N. Y.

June 4-7, 1956 — Edison Electric Institute, 24th Annual Convention, Atlantic City, N. J.

Week of June 10, 1956—National Association of Electrical Distributors (48th Annual Convention), Ambassador-Chelsea Hotels, Atlantic City, N. J.

June 11-15, 1956 — Technical Conference on Plastics, New York Coliseum, New York, N. Y.

June 25-29, 1956—American Institute of Electrical Engineers, (Summer & Pacific General Meeting), San Francisco, Calif.

June 27-July 5, 1956—International Electro Technical Committee, Munich area of Southern Germany.

October 1-5, 1956—American Institute of Electrical Engineers (Fall General Meeting), Morrison Hotel, Chicago, Ill.

October 2-4, 1956—Canadian Electrical Manufactureres Association (12th Annual Meeting), Sheraton Brock Hotel, Niagara Falls, Ontario, Canada.

October 7-12, 1956 — Society of Motion Picture and Television Engineers, Ambassador Hotel, Los Angeles, Calif.

October 22-24, 1956 — American Standards Association, 38th Annual Meeting (In conjunction with Seventh National Conference on Standards), Hotel Roosevelt, New York, N. Y.

October 22-26, 1956—National Safety Council, 44th National Safety Congress & Exposition, Chicago, Ill.

November 12-16, 1956—National Electrical Manufacturers Association (Annual Meeting), Traymore Hotel, Atlantic City, N. J.

January 21-25, 1957 — American Institute of Electrical Engineers, Winter General Meeting, Hotel Statler, New York, N. Y.

February 17-20, 1957 — National Electric Sign Association, Annual Convention and Exhibit, Sheraton Park Hotel, Washington, D. C.

March 11-14, 1957 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

May 6-8, 1957 — Air Conditioning and Refrigeration Institute, Annual Meeting, The Homestead, Hot Springs, Va.

May 7-9, 1957 — Chicago Electrical Industry Show, Chicago, Ill.

June 24-28, 1957 — American Institute of Electrical Engineers, Summer General Meeting, Montreal, Que.

August 28-30, 1957 — American Institute of Electrical Engineers, Pacific General Meeting, Yakima, Wash.

October 7-11, 1957 — American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

October 21-25, 1957 — National Safety Council, 45th National Safety Congress & Exposition, Chicago, Ill.

November 11-15, 1957 — National Electrical Manufacturers Association, Traymore Hotel, Atlantic City, N. J.

1906 — I. E. S. Golden Anniversary — 1956

Jacksonville:
Architects—Kemp, Bunch & Jackson
Fixtures—Westinghouse Electric Corporation

Minneapolis:
Architects—Magney, Tusler & Setter
Fixtures—Garden City Plating & Mfg. Co.

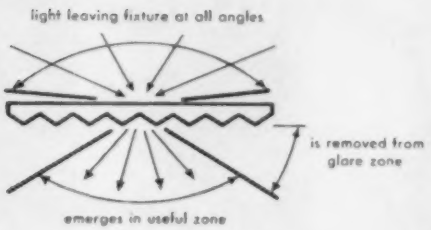
3 New

LIGHTWEIGHT PATTERN NO. 70 LENS PANEL COMES IN SEAMLESS, SINGLE-FIXTURE SIZES

Width, inches	Length, inches	Thickness	Weight, lbs. per sq. ft.
any width up to 34	any length up to 100	.180" ± .015"	1.75
cutting tolerance ± 1/16	cutting tolerance ± 1/32		

Note the excellent desk top illumination in this typical Prudential Insurance work area.

Chicago:
Architects—Naess & Murphy
Fixtures—Day-Brite Lighting Inc.



OPTICAL ACTION

In this cross-sectional diagram, you see how the prisms intercept all the light trying to pass at high "glare-zone" angles, bend it downward to useful zones. You can see how light approaching at more vertical angles is spread evenly by the prisms. The result is even illumination over the working area.

Prudential buildings use Corning Pattern No. 70 Low-Brightness Lens Panels

Regionalized exteriors give these Prudential Insurance Company of America buildings a look of "belonging" in widely separated parts of the country.

Interiors, however, have one pleasing element of resemblance: illumination. All use Corning Pattern No. 70 Low-Brightness Lens Panels. The Prudential has used nearly 30 miles of this prismatic panel to light general work areas and executive areas with soft, glare-free, shadowless illumination. Desk-top illumination is designed for 40 foot-candles maintained.

Cleaning the panels with a damp cloth will *keep* illumination high. Panels are troffer length, too. No seams to leak light or let in dust and insects.

Prisms at work

Corning Pattern No. 70 Panels are made of crystal glass with a configuration of hexagonal prisms. Prisms intercept light trying to pass at glare-zone angles, bend it downward to useful zones. Light angled more vertically is spread evenly in the useful area.

You can use Corning Pattern No. 70 Low-Brightness Lens Panels wherever you want controlled surface brightness, lasting efficiency, attractive initial cost, absence of replacement due to aging, warping, surface deterioration. Wherever you use it, you can expect an enthusiastic reaction from your client.

For detailed information, see Sweet's Catalog, or write to Corning for Bulletin L110B.

CORNING GLASS WORKS, CORNING, N. Y.
61-2 Crystal Street
Corning means research in Glass

Developed through the search for lighter, stronger structural materials to go into faster-than-sound aircraft, HEXCEL aluminum honeycomb is accomplishing feats of strength never before equalled by light-weight metal. From the honeycomb wings of the Matador to the outside curtain wall construction of a towering skyscraper—there are a score of amazing new uses for this versatile performer! One of the most recent—and most miraculous—applications for HEXCEL honeycomb is for interior lighting in schools, stores, and offices. If you have a problem that you think honeycomb can solve, telephone or write to HEXCEL Products, Inc., 951-61st Street, Oakland 8, California.

HONEYLITE . . . *the last word in visual comfort!*

Picture an all-aluminum ceiling composed of thousands of hexagonal honeycomb cells, casting shadow-free, luxuriant light into every corner of the room...a ceiling whose neutral shading harmonizes with any color scheme or any decor. Picture a ceiling that will always look new, whose aluminum honeycomb panels, suspended under lighting units, will not crack from heat or discolor with age. Such a ceiling can be yours with **HONEYLITE,** the new light-diffusing material that has the following remarkable characteristics:

- Transmits light with 95%—plus efficiency
- Non-flammable and UL approved
- Weighs only two ounces per sq. ft.
- Permits free circulation of air around light units
- Provides lowest surface brightness obtainable
- Has a noise reduction coefficient of .46

BRIDAL SALON, JOSEPH MAGNIN S. SAN FRANCISCO VICTOR GRUEN, A. I. A.

HONEYLITE
(shown at right actual size) installation is simple, inexpensive. For full ceilings, aluminum T-bars are used to suspend **HONEYLITE** panels below lighting units. **HONEYLITE** is also ideal for use in troffers and lighting fixtures.

HONEYLITE

Light-diffusing acoustical aluminum honeycomb

A development of **HEXCEL PRODUCTS INC.**

Producers of HEXCEL aluminum honeycomb – the wonder material

Operation I.E.S.

The Anniversary Issue of ILLUMINATING ENGINEERING must make every I.E.S. member proud of his Society—and justly so! Fifty years of lighting progress is unfolded in a most dramatic manner. That issue of I.E. presents for the first time within a single cover, historical achievements in lighting, the likes of which have never been published before. Undoubtedly, it will serve as an "encyclopedia" to those who are directly and indirectly interested in the lighting profession. It will find its place on the shelves of every technical library and many non-technical libraries as well. It is a masterpiece if there ever was one!

How did it get done? And who did it? As with other works of the Society, it is difficult to single out individuals for special acclaim, though several must certainly deserve it. The list of credits on page 156 of the January issue shows that a very impressive group of experts participated, giving time, thought and work for several months, delving into the past to uncover interesting facts that might otherwise have been lost forever. Working in the direction outlined for the issue by the editor, the "teams" and individual contributors brought forth some extremely interesting material on light's progress. There were many "behind the scenes" workers as well, however. As an example, Jerry Stair, our latest recipient of the Gold Medal Award, worked up the excellent material on equipment. In its development, he received suggestions, support and help from possibly a hundred or more people in the lighting equipment business. Similarly, the Street Lighting section owes its excellence to many, many experts not shown on the credit page, and no doubt many other sections as well.

All the material had to be coordinated, of course, written, rewritten, polished, and presented graphically for the reader's interest. For this we can certainly thank our editorial staff. What a tremendous job it must have been! Although the job started well over a year ago, with the editor's first outline and requests to participate, the task of correlation of material received was gigantic. One can imagine the problems involved with writing and/or organizing the material received, and the arduous task of the final weeks of its production — layout, make-up, proofreading, checking, and a thousand final details. Projects like the Anniversary Issue don't "just happen." They take a tremendous amount of creative thinking and professional know-how, plus many hours of hard work.

So, to our cherished Editor, Ruby Redford, our congratulations! And to her Assistant, Barbara Lamson, and her Secretary, Alice Stevens, a vote of thanks for jobs well done! The Anniversary Issue will live in the memory of all of us, and will be a milestone forever in the Society's achievements.

While laurels are being passed out, our appreciation also to Clayton Ellis for the record-breaking advertising in the Anniversary Issue. And to his staff, Adelaide Philiba and Eileen Keniston. Here again, a group of professionals did a major league job, with very successful results.

The January issue is only part of the Society's Golden Anniversary celebration. There is now underway a tremendous local and national program under the able direction of Dick Slauer, Chairman of the Golden Anniversary Committee. Some 35 Sections and Chapters have already held extremely successful Anniversary meetings, luncheons or banquets, formats and details of which were outlined by the committee. Text for speeches to be presented locally, and full sets of slides, prizes, etc., to be used have been completely prepared by this energetic chairman, and shipped to all Sections and Chapters planning celebrations.

The success of the Fiftieth Anniversary year bids well to exceed the officers' fondest hopes.

At that, the Society has much to celebrate! In growth alone, the picture is most interesting. The list of Charter members, those joining during the first three months of 1906, totals 190. From that we have grown to a current membership of 8350 (see chart). Size in numbers of members is, of course, only part of the story. The greatness of any organization lies in its aims and ideals, and how these benefit humanity. The aims and ideals for I.E.S. were spelled out in part by its founding fathers, and further developed by far seeing conscientious men over the years — and have indeed benefited humanity. The achievements of the Society have been important factors in the superior standard of interior environment most Americans work in, and live in, today. G. J. TAYLOR, *General Secretary.*

Lighting Fundamental Course Presented in Montreal

The Department of University Extension of McGill University and the Montreal Section of I.E.S. are offering a 10-week course in Lighting Fundamentals and Design, which started January 17. Lecturers for the two-hour sessions are R. S. Tate and A. H. Mendel, both I.E.S. members. Course Director is D. W. Frick, also a member of the Montreal Section.

The program being offered is as follows:

January 17 — Light and Sight — Terms and Measurements.
January 24 — Incandescent and Discharge Lamps.
January 31 — Fluorescent Lamps and Auxiliary Equipment.
February 7 — Quantity and Quality of Light.
February 14 — Lighting Systems — Fixture Evaluation.
February 21 — Lighting Design.
February 28 — School and Office Lighting.
March 7 — Store Lighting.
March 14 — Industrial Lighting.
March 21 — Exterior Lighting.

Tuition for the course, which is being held at the Engineering Building of McGill, is $20.

Wiring Methods and Controls — Theme of AIEE Course

A study on New Wiring Methods and Controls for Lighting is being sponsored by the Illumination Division, New York Section of the American Institute of Electrical Engineers. The weekly sessions, which started February 8, are being held in the Auditorium of the

(*Continued on page* 18A)

(*Continued from page 17A*)

General Electric Co. Building in New York City. The weekly sessions are as follows:

1. Selection of Secondary Distribution for Lighting.
2. Electrical Characteristics of Light Sources and Auxiliaries.
3. Commercial and Industrial Lighting Equipment.
4. Lighting Layout Techniques: General Interior Illumination.
5. Lighting Layout Techniques: Special Problems (Black Light, Floodlighting, Luminous Advertising, Inspection, etc.).
6. Lighting Branch Circuits and Protection.
7. Code Requirements for Lighting.
8. Lighting Equipment Installation Methods.
9. Estimating Costs.
10. Adequate Wiring Requirements.

S. H. Hazleton is Chairman of the Education Committee under whose auspices the study group is operating.

National Electrical Week Held This February

The week of February 5 1956 was designated at National Electrical Week, which will be observed annually as a coordinated project under the sponsorship of the electrical industry. Merrill E. Skinner, Vice President of Union Electric Co. of Missouri and chairman of the National Electrical Week, described the objectives of the week as

(1) To focus attention on the contributions of electricity to our way of life and on the contributions toward the economic strength of the country by the organizations which make up the electrical industry.
(2) To emphasize the contribution to safety that can be accomplished through adequate electrical wiring installations.
(3) To encourage the appropriate recognition of electrical pioneers, from whose inventive genius came so many contributions to the industry as we know it today, by selecting for this annual event the week in which falls the birthday of Thomas Alva Edison.

ABOUT PEOPLE

At the annual meeting of the Board of Directors of the Chicago Lighting Institute, December 28th, the following officers were elected for the coming year. For President, **O. A. Hill,** superintendent, Light Bulb Service, Commonwealth Edison Co., and a Past-Chairman of the I.E.S. Chicago Section. For Vice-President, **Frederick H. Heintz,** Midwest Sales Manager, Lighting Division, Sylvania Electric Products, Inc. For Secretary-Treasurer, **R. J. Diefenthaler,** Sales Administrator, Chicago Sales District, Large Lamp Dept., General Electric Co., and currently Chairman of the I.E.S. Chicago Section. **Carl W. Zersen** was reappointed Managing Director and Assistant Secretary-Treasurer.

WINNING ticket for one of the door prizes for ladies is drawn by Mrs. Donald Prideaux at the Southern California Section's Ladies Night meeting December 7. At left is George A. Hochenauer, Vice-Chairman of the Section, and Harold Hall, Chairman of the Door Prize Committee.

L. C. Barber has been appointed Product Manager, Lighting, for the International Division of Sylvania Electric Products Inc., with headquarters in New York City. Mr. Barber was previously associated with the International General Electric Co., as manager of lighting sales.

A new president, vice-president and two directors have been named by the Inter-Society Color Council. New president of the group is **Waldron Faulkner** of Faulkner, Kingsbury and Stenhouse, Washington architectural firm. Mr. Faulkner was previously a vice president of ISCC. The new vice-president is **Walter C. Granville,** assistant director of the department of design, Container Corp. of America. **Ralph E. Pike** and **G. L. Erickson** are the two new directors. **Ralph M. Evans** was re-elected secretary and **Norman Macbeth** was re-elected treasurer. Other directors remain **Helen D. Taylor, Scott Wilson** and past president, **Dorothy Nickerson.**

Frank M. Tait, dean of the public utilities industry, has formed the Frank M. Tait Foundation in Dayton, Ohio, for charitable, scientific, educational and religious purposes. To start the Foundation, Mr. Tait, a former associate of Thomas Edison, will place into it assets of the Dayton Pump and Manufacturing Co., of which he is founder and chairman of the board of directors.

Charles C. Beyer has been appointed district sales manager, lighting products, for the newly formed Charlotte, N. C., district by Sylvania Electric Products Inc. The district includes North and South Carolina, Kentucky, Virginia and Tennessee. Mr. Beyer, who has been with the company since 1949, will make his office at 225 South Tyron St., in Charlotte.

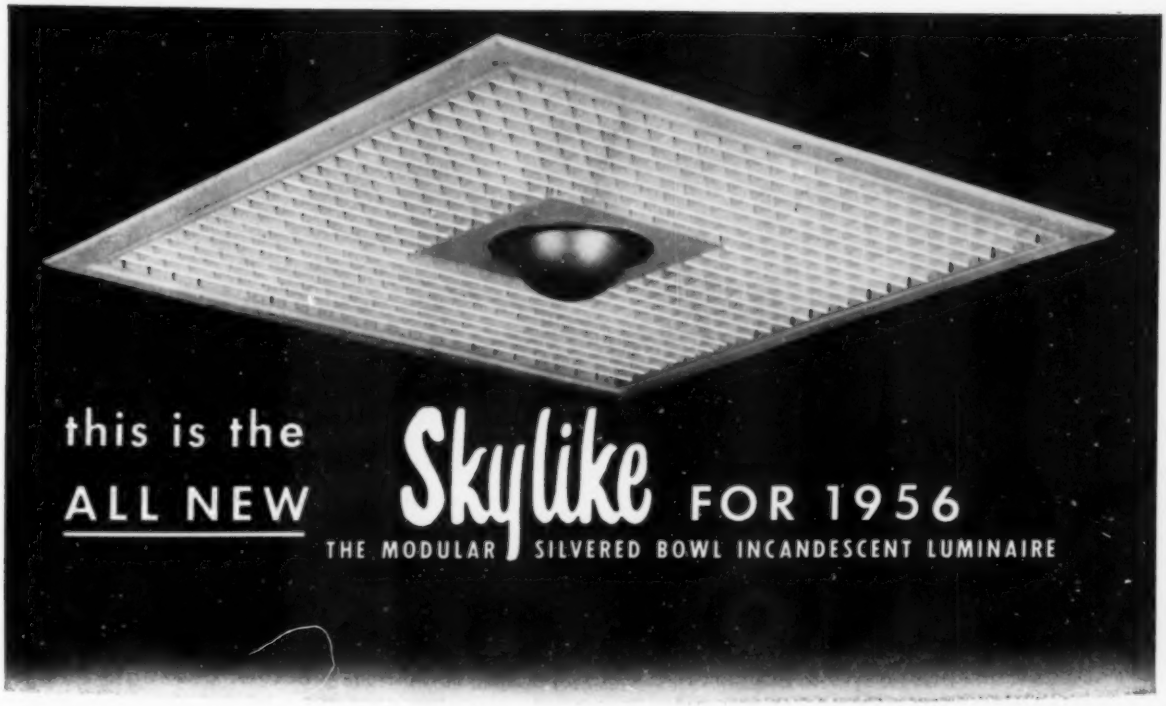
James R. Bailey has been named sales manager of the ballast division of Jefferson Electric Co., Bellwood, Ill. A Jefferson man for 14 years, Mr. Bailey has served in just about every phase of the transformer business, and for the past two years has been central district sales manager.

Five section managers for the General Electric Co.'s new Medium Transformer Department have been named by **David B. Lawton,** department general manager. All have been serving in similar posts for the Rome, Ga., plant, which on January 1 became a separate product department of the company. They are: **Theodore F. Voskmer,** manager, engineering; **David Hopley,** manager, manufacturing; **Christopher T. Kastner,** manager, marketing; **Wilbur A. Bethel,** manager, finance; and **George D. Austin,** manager, employee and plant community relations.

James J. Lawler, safety engineer for the Radio Tube Division of Sylvania Electric Products Inc., has been elected general chairman of the Electrical Equipment Section of the National Safety Council for a term of one year. This Section encompasses most of the electrical and electronic manufacturers throughout the United States and Canada.

The Chief of Army Engineers, Lieutenant General Samuel D. Sturgis, Jr.,

(*Continued on page 21A*)



this is the
ALL NEW **Skylike** FOR 1956
THE MODULAR SILVERED BOWL INCANDESCENT LUMINAIRE

WITH FOUR NEW FEATURES

- All units are **PRE-WIRED**
- All units are **COMPLETELY ASSEMBLED**
- New construction provides **EASIER INSTALLATION**
- One basic unit for any type of ceiling construction

AND WITH THIS ADDED...

Skylike is now lower in cost

To meet increasing demands, Skylike has developed new production techniques making possible vastly improved units and lower costs. These advantages are being passed directly on to users. For complete detail write to...

SKYLIKE---THE **FIRST** AND **FINEST** IN MODULAR SILVERED BOWL INCANDESCENT LIGHTING

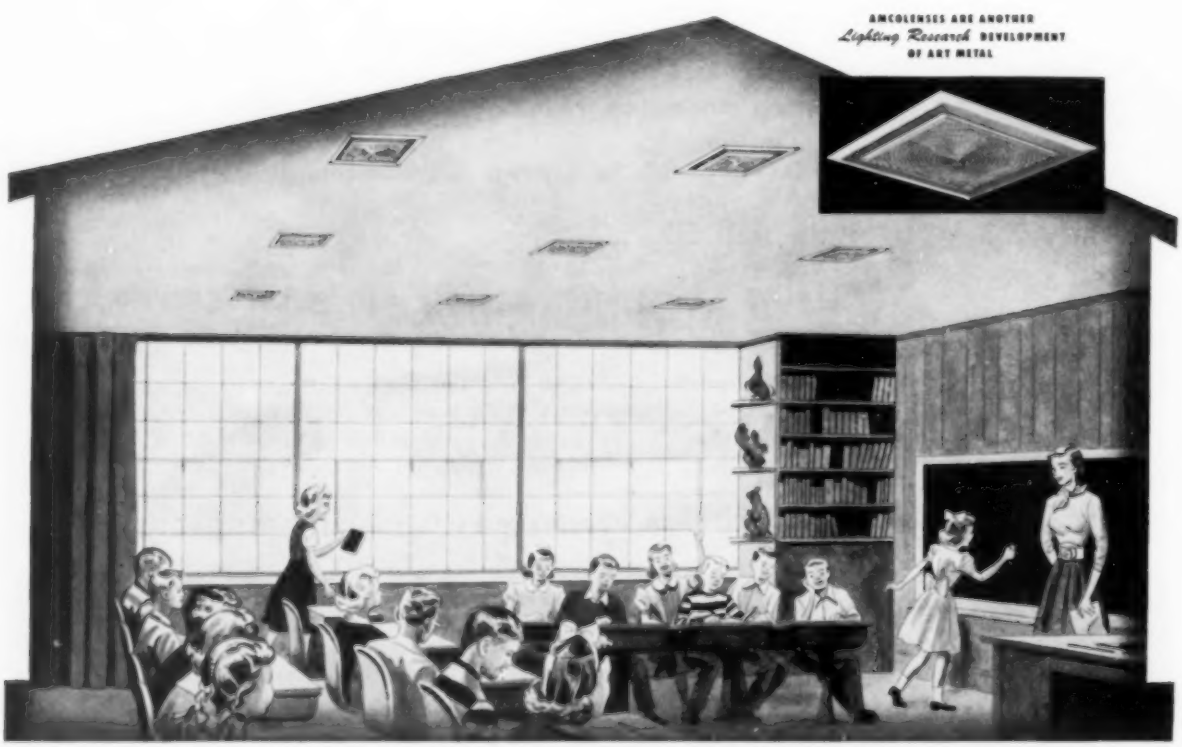
SKYLIKE LIGHTING, INC.
A SILVRAY ASSOCIATED COMPANY
Bound Brook, New Jersey
RKO Bldg., New York 20, N. Y.

children and teachers are enjoying school this year

BETTER SEEING FOR SCHOOLS

The schoolroom is brighter these days thanks to the Art Metal AMCOLENS, the most exciting lens development in the history of artificial lighting. *Never* have the wall maps looked so fascinating – the work books so colorful, the desks, walls, woodwork so visually comfortable. Here's the reason! Amcolens *is clear prismatic glass!* Because it is crystal clear, it achieves *undiminished light transference efficiency* and *unaltered white lamp light transference.* Because it is composed of glass prisms — the most exact method known to control light — it introduces *precise light direction control.* Housed in either Art Metal recessed eliptisquares, eliptispheres or a variety of recessed and surface attached equipments, Amcolenses make the whole school come alive, brighter and more cheerful. There are Art Metal incandescent lighting designs for all types of school applications.

THE **ART METAL** COMPANY
CLEVELAND 3, OHIO



(Continued from page 18A)

has announced the appointment of **Major General Louis W. Prentiss** as Commanding General of the Engineer Research and Development Laboratories, Fort Belvoir, Va. **Colonel H. F. Sykes, Jr.,** who has commanded the Laboratories since July 1954, has been named Director, and the agency has been designated a Class II activity directly responsible to the Chief of Engineers.

BOOKS AND PAMPHLETS

Books whose reviews are marked * are available for inspection at I.E.S. Headquarters, Technical Department.

***How to Decorate and Light Your Home,** by E. W. Commery and C. Eugene Stephenson, published by Coward-McCann, Inc., New York, N. Y., 1955, 256 pages illustrated and indexed. $6.75.

Prepared as a complete self-contained guide to the basic principles of decorating, this is the first time a decorating book has combined color and light to show effects created during daylight hours may be maintained at night under electric illumination. The authors have combined decoration and light in a well-integrated yet informal manner, showing that it is not necessary to start from scratch to create a satisfactory interior. Instead, the reader is able to create his own decorating schemes using the basic tools of decoration and the basic units or groupings given in the book.

Subjects treated are: Planning Your Home for Living; About Color and Light; Beginning Your Color Plans; Creating Your Color Scheme; Twenty-Eight Room Color Schemes; Walls and Windows, Ceilings and Floors; Grouping Your Furniture; Forty-Three Ways to Group Furniture; Assembling and Arranging Your Rooms; Selecting and Organizing Accessories and Lamps; Decorating and Lighting Porches and Terraces; Thirty-Five Methods for Lighting Your Home. Twenty-eight room color schemes and more than 150 black-and-white drawings have been used to illustrate various points throughout the book. Included in the appendix are various color guides and definitions, a lumen data sheet and lumen chart, and a lighting guide to illustrations.

Mr. Commery is a Fellow of the Illuminating Engineering Society, and is at present in charge of residential lighting for the General Electric Company. Mr. Stephenson is a Past President of the American Institute of Decorators, and is a member of the Board of Trustees of the Parsons School of Design.

FOUR members of the Cleveland Section of I.E.S. received their certificates elevating them to the grade of Fellow at the Section's January 5 meeting. George Warner, Section Chairman, at far left, and l. to r., the new Fellows: C. E. Weitz, Mary E. Webber, Art C. Barr, and W. A. Pennow.

APPROXIMATELY 200 persons attended the Ladies Night meeting of the Cleveland Section, I.E.S., to hear H. H. Magdsick, E. W. Commery, Mary E. Webber and Alston Rodgers.

***The ISCC-NBS Method of Designating Colors and a Dictionary of Color Names,** United States Department of Commerce, National Bureau of Standards Circular 553, Issued November 1, 1955. Available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D .C. $2.00.

As stated in the preface, "The purpose of this dictionary is to assist the scientist, businessman, and layman to understand the different color vocabularies used in the many fields of art, science, and industry. Some of these vocabularies are very similar, in fact they borrow from one another, while others are nearly or completely unintelligible to workers in another field. The dictionary will serve not only as a record of the meanings of the 7,500 individual color names listed but will also enable anyone to translate from one color vocabularly to another.

(Continued on page 22A)

(*Continued from page* 21A)

As an example, what is the meaning of Grisco-Viridis? This dictionary shows that Grisco-Viridis (biology) = Serpentine (fashion) = Mint Green (mass market), or in ordinary language, a light green.

The terms by which this dictionary defines color names are those of a refinement of the method of designating colors outlined by the Inter-Society Color Council and developed at the National Bureau of Standards."

***Lighting the Stage,** by P. Corry, published by Pitman Publishing Corporation, 2 West 45th St., New York 36, N. Y., 157 pages, illustrated and indexed. $4.50.

This British book is intended for those people primarily concerned with the use of light on the stage, and only incidentally with the use of electrical apparatus. Technicalities are discussed only in such detail as is necessary to show what standard stage lighting equipment will do, without requiring an understanding of the electrical and mechanical reasons behind it. Emphasis is placed on the fact that there is rarely an absolutely right or wrong way in stage lighting.

The wide scope of the book is shown by the following chapter titles: The Producer's Responsibility; Why Lighting Is Important; What Must Be Lighted; Borders and Ceilings; Curtain Settings; Scenery Settings; Stage Lighting Equipment; Lighting Control Equipment; Colour in Light; The Cyclorama; Cyclorama Lighting; Lighting Design; Typical Lighting Problems; Optical Effects and Scene Projection; Trick Lighting and Special Effects; Scenery, Lighting and Dress Rehearsals; The Performance; The Platform Stage; Postscript. Appendices include a bibliography, a list of interchangeable scenery flats, and a graph indicating focal length of lens in relation to distance of throw and size of picture required.

IT SEEMS TO ME

Brightness Meters For Model Studies

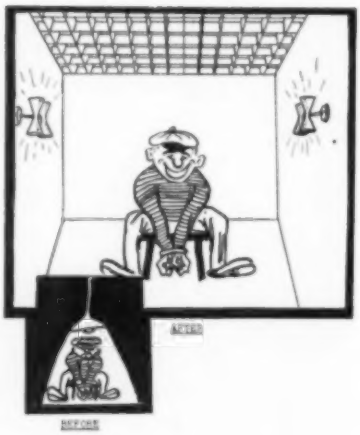
I read with interest the article by E. E. Vezey, "A Brightness Meter for Use in Model Studies of Buildings." (I.E., November 1955). I should like to submit a report of analyzing the instrument by myself and our engineers:

"The diameter of the area measured by Mr. Vezey's instrument is approximately ½ of the distance from the meter to the subject, *plus two inches.* This means that no matter how close one is able to approach the subject, the area measured is never less than two inches (the diameter of the cell-baffle system.

"The pickup has no sighting means on it, but since it is used so close to the subject and the area measured is so large, this is probably not so much of a limitation as the large area of coverage. It would seem that the models would have to be quite large in order to keep this relatively large field of view from limiting the accuracy of the analysis. If the model is fairly large, then there is little advantage in the slightly smaller size (approximately 2¼-inch by 4-inch by 5-inch) as compared with the Spectra Brightness Spot Meter's dimensions (3-inch by 5¾-inch by 9-inch). Particularly when one considers that the Vezey meter still has to be connected to a sensitive galvanometer with a one-meter scale distance which has to be carefully handled, leveled and supported free from vibration.

"The ideal instrument for the analysis of model buildings should have a field of view in keeping with its reduced size. If the field of view is small then there should be adequate sighting means provided to make sure the desired area is that being measured. It is often convenient to have the microammeter connected to the pickup with a cable so it can be located in the most convenient position for reading, but it should be a rugged, readily portable, compact instrument.

"The use of supplementary lenses with the Spectra Brightness Spot Meter enables it to be used at the close distances required for evaluating the illumination in models and keeps the diameter of the area measured in keeping with the size of the model. At a distance of 20 inches the 1½° Model covers an area ½ inch in diameter, while the ½° Model covers 1/6 inch. At 10 inches the areas measured are ¼ and 1/12 inch respectively. If one desires to cover still smaller areas, the special four-element "Spectar" Supplementary Lens can be used to measure 1/10 or 1/30 inch at a distance of two inches from the end of the lens. These smaller areas of measurement enable the engineer to make as complete an analysis of the model as he would make from the full scale construction." — KARL FREUND, *Photo Research Corp., Hollywood, Calif.*



"Most Interesting Lighting Job?"
This installation could win a prize! Stimulus for entering the St. Louis Section's contest for My Most Interesting Lighting Job is offered by this sample installation, the work of Norman Krause, Chairman of the Section's MMILJ Contest Committee. It is described as "Original, Practical, Useful and Good I.E.S. Practice."

NEW MEMBERS

At the meeting of the I.E.S. Council Executive Committee, held in New York, N. Y. on January 12, 1956, the following were elected to membership. Names marked * are transfers from Associate Member grade.

ARIZONA SECTION

Member:
*Brown, A. W., 4203 N. 11th, Phoenix, Ariz.
Associate Member:
Lott, J. E., Arizona Public Service Co., Yuma, Ariz.

ARK-LA-TEX CHAPTER

Associate Member:
Flowers, R. G., General Electric Co., Shreveport, La.

BLUENOSE CHAPTER

Members:
Ford, F. C., Box 820 Armdale, Halifax, N. S
Fowler, C. A. E., C. A. Fowler & Co., Halifax, N. S.
*MacDonald, G. A., Canadian General Electric Co., Halifax, N. S.
*Wilkinson, K., Northern Electric Co., Ltd., Halifax, N. S.
Associate Members:
Buell, R. E., Northern Electric Co., Ltd., Halifax, N. S.
Priest, A. E., 428 Robie St., Halifax, N. S.
Sample, J. R., J. A. Wilson Lighting & Display, Fairview, N. S.

CENTRAL NEW YORK SECTION

Associate Members:
DeWeaver, A. F., New York State Electric & Gas Corp., Ithaca, N. Y.
Nichol, E. J., New York State Electric & Gas Corp., Ithaca, N. Y.
Wilson, W. C., New York State Electric & Gas Corp., Ithaca, N. Y.

CENTRAL OKLAHOMA CHAPTER

Associate Members:
Anthony, Tom, Public Service Co. of Oklahoma, Duncan, Okla.
Borelli, Marguerite J., Oklahoma Gas & Electric Co., Oklahoma City, Okla.

CHICAGO SECTION

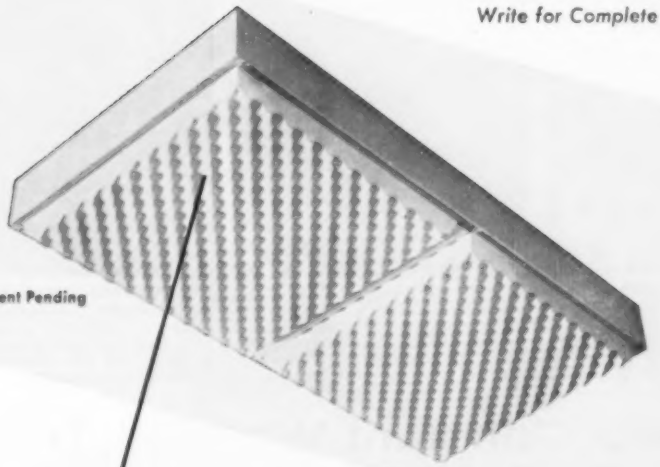
Member:
*Innis, Leslie, Sylvania Electric Products Inc., Melrose Park, Ill.

(*Continued on page* 33A)

ALL-BRITE
Fluorescent Fixtures of California

The Sensational New AREA/LITER™

An Original All-Brite Development
Product of All-Brite Research
Write for Complete Brochure



Patent Pending

All-Brite's new main plant at South San Francisco—largest and most modern in the West — now expanding to over 100,000 square feet.

ask your contractor about

Certified Lighting

All-Brite
LIGHT OF THE WEST

FLUORESCENT FIXTURES OF CALIFORNIA

Main Office and Plant: 352 SHAW ROAD • SOUTH SAN FRANCISCO
Branch Plants: 239 WEST 31ST STREET • LOS ANGELES 7
1318 S.W. FIRST AVENUE • PORTLAND 1

THREE PLANTS TO SERVE THE WEST

LINE VOLTAGE DROPS TO 80V ON SOLA CONSTANT-WATTAGE BALLASTED INSTALLATION: *"Outages" are prevented due to the patented constant wattage circuit in Sola Mercury Vapor Lamp Transformers. Even when line voltage drops as low as about 75v on a 115v line, lamps stay lit, eliminating the need for "auxiliary" incandescent or fluorescent lighting installations.*

LINE VOLTAGE DROPS TO 80V ON CONVENTIONALLY-BALLASTED INSTALLATION: *Line voltage drops often cause outages. Until lamps return to strikeable condition, vital minutes of production time may be lost in industrial installations; safety hazards may exist in parking lots (as shown above) or playgrounds or plant area protection applications.*

Sola Constant Wattage Transformers For E-H1 400w Mercury Vapor Lamps End Outages Due to Line Voltage Drops

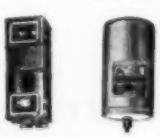
When your mercury vapor lighting installation is ballasted with Sola Mercury Vapor Lamp Transformers, you can rely on dependably-maintained light output. First, outages are virtually eliminated since primary voltage must drop below about 75v on a 115v line before lamps extinguish. Second, the Sola Patented Constant Wattage Principle assures lumen regulation within $\pm 2\frac{1}{2}\%$, even in the face of line voltage variations as great as $\pm 13\%$.

In addition, Sola Constant Wattage Mercury Vapor Lamp Transformers offer the following advantages over conventional ballasts:

- Eliminate the need for primary taps . . . positive starting within the primary ranges of 100 to 130 and 200 to 260 volts.
- Low starting current surge . . . line current during starting interval limited to effectively no more than normal full load value.
- Open and short-circuit protection . . . primary current positively limited under abnormal operating conditions of lamp failure, or external short circuit . . . constant wattage circuit eliminates any lamp electrode rectification.
- Extended lamp life . . . regulated voltage, current, and wattage permit continuous, stable operation, resulting in superior lamp life.
- Low crest factor . . . (peak/rms ratio) of lamp current averages only 1.7 at 115v primary supply.

It will pay you to investigate the advantages of Sola-ballasted mercury vapor lighting installations for both indoor and outdoor high intensity lighting applications. Request your Sola representative to call.

SOLA *Mercury Vapor Lamp* **TRANSFORMERS**



Write on your letterhead for Bulletin 3B-MV-219.

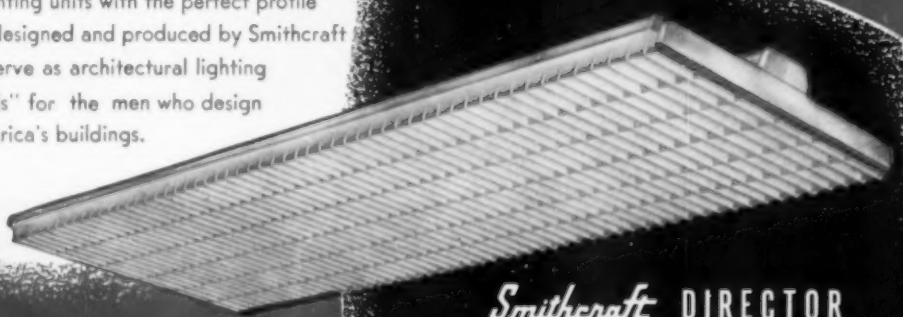
CONSTANT VOLTAGE TRANSFORMERS for Regulation of Electronic and Electrical Equipment • **LIGHTING TRANSFORMERS** for All Types of Fluorescent and Mercury Vapor Lamps. • **SOLA ELECTRIC CO.**, 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414 • *NEW YORK 35: 103 E. 125th St., TRafalgar 6-6464 • PHILADELPHIA: Commercial Trust Bldg., Rittenhouse 6-4988 • BOSTON: 272 Centre Street, Newton 58, Mass., Bigelow 4-3354 • CLEVELAND 15: 1836 Euclid Ave., PRospect 1-6400 • KANSAS CITY 2, MO.: 406 W. 34th St., Jefferson 4382 • LOS ANGELES 23: 3138 E. Olympic Blvd., ANgelus 9-9431 • TORONTO 9, ONTARIO: 617 Runnymede Rd., RO 7-1654 • Representatives in Other Principal Cities*

THE LIGHTING UNITS WITH
the perfect profile!

Here is ideal lighting that integrates with modern building design . . . lighting units so shallow they blend perfectly with overhead architecture. Here is fluorescent lighting that, in hundreds upon hundreds of installations across the country, is fulfilling the architect's request for clean, uncluttered lines. Here are fixtures that, because of their highly desired shallowness, have been called "the lighting units with the perfect profile"!

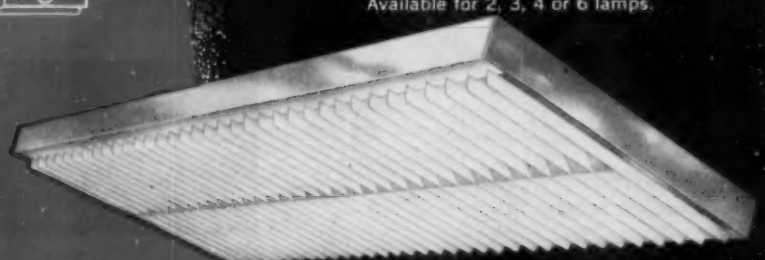
Appearance, however, is only a part of the reason for the success of these two outstanding Smithcraft fluorescent fixtures. Their lighting performance is highly efficient, and their availability in several combinations and lengths of lamps make them adaptable to any installation.

"Lighting units with the perfect profile" . . . designed and produced by Smithcraft to serve as architectural lighting "tools" for the men who design America's buildings.



Smithcraft DIRECTOR

An extensive yet unobtrusive "area of light" source . . . up to 37" wide and extremely shallow in appearance. Available for 2, 3, 4 or 6 lamps.



Smithcraft SHERATON

Only 3¼" deep . . . translucent plastic sides . . . a modern, trim lighting unit, ideal for low-ceiling applications. Available for 2 lamps or 4 lamps.

Send today for complete information on the Smithcraft DIRECTOR and SHERATON!

America's finest fluorescent lighting...

Smithcraft
LIGHTING DIVISION
CHELSEA 50, MASSACHUSETTS

ATTENTION:

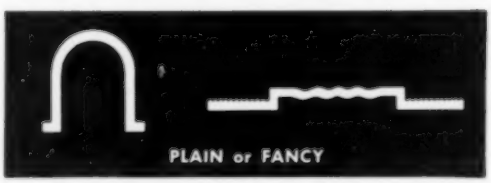
Mr. Manufacturer
Mr. Designer
Mr. Purchasing Agent

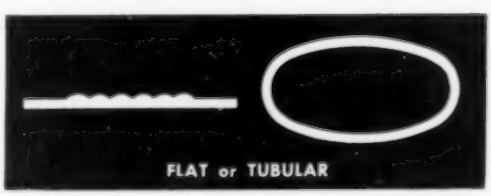
ROTUBA

PLASTIC PANELS UNLIMITED

Here at Rotuba, our plant is equipped to extrude panels for YOU without any limitation. In any plastic — POLYSTYRENE, LUCITE, PLEXIGLAS or BUTYRATE. In any shape, standard or custom–made . . . any size . . . with any degree of light transmission.

You can benefit now from our ten years of successful extrusion experience. Send us a sketch of your latest panel-design, or send sample of panel you are currently using. We'll gladly quote on it. Don't delay, do it today!





For fast dependable service . . . economical, too, contact

ROTUBA EXTRUDERS, INC.
418 88th STREET • BROOKLYN 9, NEW YORK
SHore Road 8-5458

Makers of
PANELS • SHIELDS • DIFFUSERS
IN PLASTICS

Phila. Office
R. L. BOUSE, FLOURTOWN, PENNA.
Tel. CHESTNUT HILL 8-1010

High Level Lighting for Faster Learning... with Lighting by **LITECONTROL**

Better lighting helps young minds learn faster, more comfortably in this remodeled Harrisburg, Pa., school. Both the original building (above) and the new wing now have their classrooms entirely lighted by LITECONTROL.

LITECONTROL fixture No. 6628 gives plenty of high intensity, low brightness illumination everywhere. Efficiency is an unusually high 86%. Light through the top of the fixture cuts fixture-ceiling contrast and helps minimize glare.

Two-piece construction means installation is fast and simple, whether the units are hung individually or in continuous rows. Maintenance is easy, too: baffles swing fully open from either side without the use of tools. Fixtures may be cleaned and relamped in seconds.

Whether your job is lighting or relighting, for a custom installation at standard fixture prices, get in touch with LITECONTROL. Call or write your local representative.

INSTALLATION: Hamilton Elementary School, Harrisburg, Penna.

ARCHITECT: Clayton J. Lappley, Harrisburg, Penna.

ENGINEER: Snyder & Van Horn, Harrisburg, Penna.

ELEC. CONTRACTOR: The Howard P. Foley Company, Harrisburg, Penna.

FIXTURE: Litecontrol No. 6628 and 6624, pendant mounted.

INTENSITY: New rooms (with fixtures hung on 8" stems), average 52 footcandles initially on desks.

Old rooms (with fixtures hung on 24" stems), average 47 footcandles initially on desks.

LITECONTROL *Fixtures*

KEEP UPKEEP DOWN

LITECONTROL CORPORATION, 36 Pleasant Street, Watertown 72, Massachusetts

DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

FLORA BALLAST* SHOWS how easy it is to make across-the-counter in-warranty replacement of G-E ballasts at no cost to you, from your nearby G-E Ballast Service Center Distributor. They carry ample stocks of G-E ballasts from which you can select replacements for any make ballast.

Flora explains how . . .*

More Than 800 G-E Ballast Service Centers Help You Save Lighting Dollars

When it is necessary to obtain an immediate ballast replacement you'll get prompt service at the G-E Ballast Service Center Distributor located nearest you. The complete stocks and convenient location help you save time and money. There are G-E Ballast Service Centers in every major city—more than 800 of them in the United States. Here you can make NO CHARGE in-warranty replacements of G-E ballasts . . . and replace *any make* ballast with a high quality G-E unit. And G.E. gives you top quality at low attractive prices too. Save time and money—solve your ballast replacement problems at your nearest G-E Ballast Service Center.

When you buy G-E ballasts you get other services too. G.E. maintains a network of national warehouses to speed volume orders. More than 150 trained sales engineers from G-E Apparatus Sales Offices are available to give you help in applying G-E ballasts and in servicing G-E ballast installations.

A G-E ballast tag or sticker on your fixture is proof that it is equipped with the best in ballast value. It's the easy way to be certain. For a complete presentation on G-E ballasts, contact the G-E Apparatus Sales Office nearest you or write Section 401-16, General Electric Company, Schenectady 5, New York.

*Miss Fluorescent Ballast, G.E.'s Ballast Mascot

Copyright 1955, General Electric Company

EXPERIENCED G-E BALLAST ENGINEERS are available to help you plan and service fluorescent lighting applications. For help, contact your nearest G-E Apparatus Sales Office.

Five more reasons why

GENERAL ELECTRIC IS YOUR BEST BALLAST VALUE

- EXCLUSIVE SOUND RATING SYSTEM
- SUPERIOR QUALITY CONTROL
- LONGER BALLAST LIFE
- PRECISE LAMP-MATCHED DESIGN
- PROVED PRODUCT LEADERSHIP

Progress Is Our Most Important Product

GENERAL ELECTRIC

Perfeclite now offers the most advanced design in incandescent ceiling pan lighting fixtures. No other ceiling pan fixture on the market today has all these advantages!

- Globe opens on *hinge* for quick easy cleaning and relamping.
- Unique *safety locking fitter* holds globe in place without bothersome screws, unsightly extensions or trick springs. Globe is secured with lugs by simple twist of the wrist.
- Lip of globe is completely protected against *breakage* by a steel protector ring.
- Provides *ceiling illumination* as well as evenly distributed floor lighting.
- Minimum amount of metal, maximum amount of glass results in *highest light efficiency.*

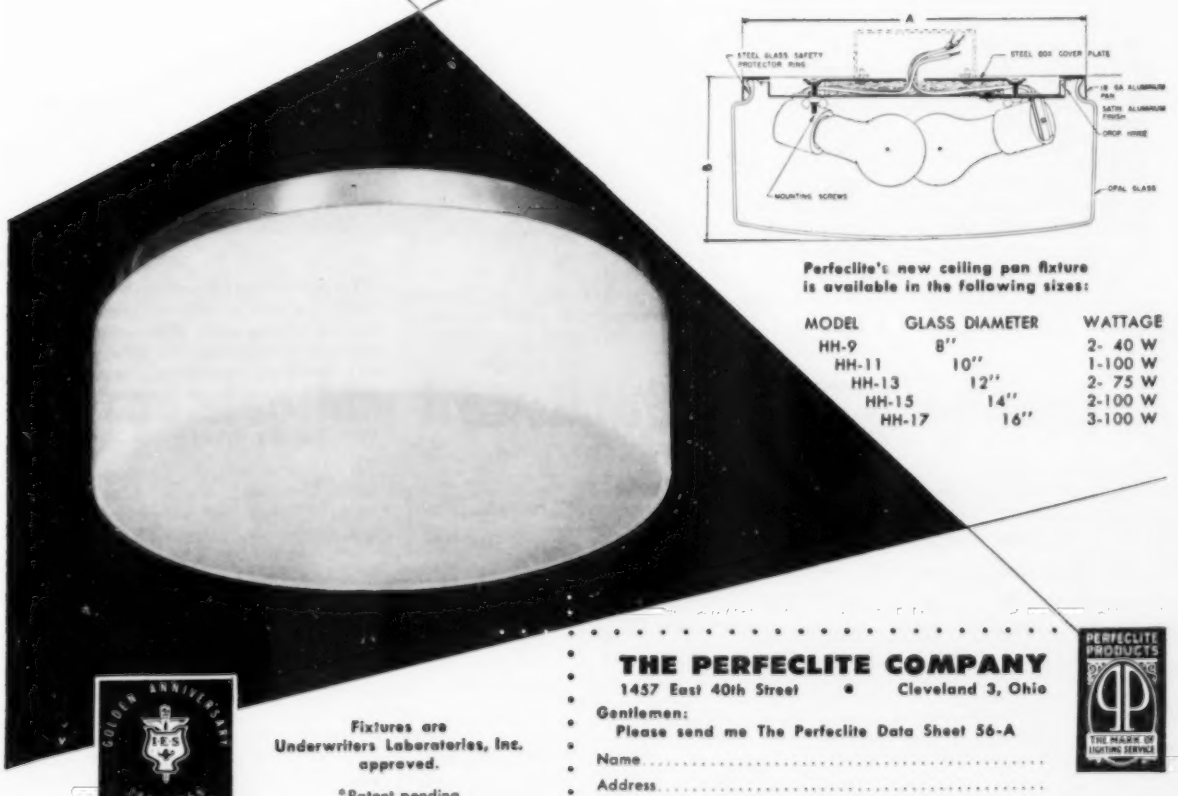
Here is a truly modern ceiling pan fixture engineered for either commercial or residential installation. For further information fill in and mail the attached coupon today.

Announcing...

*a new hinged design**

in ceiling

pan fixtures by **PERFECLITE**



Perfeclite's new ceiling pan fixture is available in the following sizes:

MODEL	GLASS DIAMETER	WATTAGE
HH-9	8"	2- 40 W
HH-11	10"	1-100 W
HH-13	12"	2- 75 W
HH-15	14"	2-100 W
HH-17	16"	3-100 W

GOLDEN ANNIVERSARY IES 1906 1956 SUSTAINING MEMBER

Fixtures are Underwriters Laboratories, Inc. approved.

*Patent pending

THE PERFECLITE COMPANY

1457 East 40th Street • Cleveland 3, Ohio

Gentlemen:
Please send me The Perfeclite Data Sheet 56-A

Name.....

Address.....

City.....State.....

PERFECLITE PRODUCTS — THE MARK OF LIGHTING SERVICE

NEW EQUIPMENT DATA
AVAILABLE WITH COUPON

New manufacturers' catalogs and bulletins listed below are available free to readers of ILLUMINATING ENGINEERING by mailing the coupon. Circle the numbers of those items which you want, drop in envelope or fasten securely to back of 2-cent postcard addressed to Publications Office.

1 Booklet Series 63300C describes new photoelectric controls for street lighting and Bulletin H-161-A is service, maintenance and application manual for same. New control designed specifically for automatic turn-on of tunnel entrance lights; has "fail-safe" action and 5-7 second time delay to prevent transient lights from operating control. Fisher-Pierce Co., Boston, Mass.

2 Folder covers new 43-40 Series of vapor and dust-tight wall brackets newly-designed for use in schools, hospitals, motels, hotels, shopping centers, and other institutional installations. McPhilben Mfg. Co., Brooklyn, N. Y.

3 Bulletin 97 on BI-FLO UPLITER, new industrial fluorescent luminaires for 48" and 96" T-12 single pin lamps; 40-watt, 48" bipin and 100-watt high output Rapid-Start lamps. Folder shows all features; light distribution pattern and coefficients of utilization. Wheeler Reflector Co., Boston, Mass.

4 New 48-page, full-color book, "Finishes for Alcoa Aluminum," presents a comprehensive and informative description of the many ways in which the appearance and performance characteristics of aluminum can be varied. Aluminum Co. of America, Pittsburgh, Pa.

5 Folder describes NEW YORKER fluorescent luminaire said to combine light and sound control in one fixture. Features include reflectors of absorbent white fibre-glass, side and bottom panels of corrugated plastic. Luminous Ceilings Inc., Chicago, Ill.

6 20-page folder on POWER-STRUT, series of specially-designed standard 12-gauge struts said to provide a wide range of beam and column loads, using standard fittings for application in construction, for carrying conduit, etc. Power Products Co., Inc., Framingham, Mass.

7 New catalog page gives data on 2- and 4-lamp fluorescent SURFACER luminaires with steel sides and GRATELITE louver bottoms; provides illumination and dimensional data with information on construction and ordering. Edwin F. Guth Co., St. Louis, Mo.

8 New narrow cross-section fluorescent lamp ballast for two 96" and 72" T-12 lamps is described in catalog sheet which includes wiring diagram and dimensionnal data as well as full specifications. Advance Transformer Co., Chicago, Ill.

9 Two catalog sheets describe new adjustable, swivel-type hospital light, several colors available, and a variety of combinations of shade-type and with or without convenience outlets and night lights in which the unit may be procured. Prescolite Mfg. Co., Berkeley, Calif.

10 Technical Data sheet covers DG-70 new extruded polystyrene light in weight and recommended for luminaire shielding because capable of light transmission values up to 70% and with exceptional hiding power; full details on light stability, discoloration, etc. Sheffield Plastics Inc., Sheffield, Mass.

11 "Wakefield Lighting: As Flexible As Your Classrooms" is a new booklet in color describing company's concept, PHOTO-METRICS, for schoolroom fluorescent lighting. Concept includes electrical channel hanging which meshes in to movable partitions and under which an aluminum grid supports a vinyl diffuser. The Wakefield Co., Vermilion, Ohio.

12 Two new booklets cover applications of mercury vapor lamps both for street lighting and for industrial purposes; describing advantages and important considerations in selecting light sources and luminaires for outdoor lighting problems. Sylvania Electric Products Inc., Salem, Mass.

13 New 64-page DATALOG shows company's complete line of commercial, institutional, industrial and outdoor lighting fixtures; explains fundamentals of light control, recommended illumination levels and design data. Complete illumination information accompanies luminaire descriptions. Holophane Co., New York, N. Y.

14 Four-page, three-color brochure features directional EDGE LITES with deep V-cut engraved letters, numbers or arrows for ceiling-counter bracket or for wall mounting. Folder gives construction and specification data. Metallic Arts of New England Inc., Cambridge, Mass.

15 New 132-page catalog and wiring guide shows complete line of surface metal raceways and fittings, including installation instructions for all sizes of raceways, and describing complete line of fluorescent and slimline equipment. The Wiremold Co., Hartford, Conn.

16 Four-page, two-color folder describes MILITE new light weight plastic said to shrink when exposed to flame making possible under sprinkler system installations of luminous ceilings. Folder gives details as to available sizes and prices, as well as lighting characteristics. Kirby Cogeshall Steinau Co., Milwaukee, Wis.

17 New 36-page architectural troffer catalog is divided into sections for selection of lighting unit; gives complete illustrations and details dimensioning data, and includes technical specifications and photometric tables for necessary data on variety of lighting applications. Smithcraft Lighting Div., Chelsea, Mass.

18 16-page booklet, "Outdoor Lighting with Plexiglas," discusses quality of light delivered and maintenance, safety and appearance features of outdoor fluorescent luminaires fitted with PLEXIGLAS diffusing shields. Photographs show wide variety of recent outdoor fluorescent installations. Rohm & Haas Co., Philadelphia, Pa.

19 Series 810 folder describes company's SPACE-LIGHTER fluorescent luminaire in 2- or 4-lamp models with moulded vinyl plastic diffuser 24" wide; gives mounting dimensions, I.T.E. curves and shows various features. Ruby Lighting Corp., Los Angeles, Calif.

Offer good for two months

Circle numbers wanted. Enter name and address. Clip out and mail.

PUBLICATIONS OFFICE 2-58

ILLUMINATING ENGINEERING SOCIETY
1860 Broadway
New York 23, New York

Send me items circled below:

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	

Name .....

Company .....

Street .....

City ..... Zone ..... State .....

slimline LEAD-LAG ballasts . . .
for lighting economy

Above fixture equipped with series ballast. Lamp on right has burned out, causing left lamp to burn at reduced light output. With *lead-lag* ballast, left lamp would burn at full output.

You can stop him from throwing out good lamps!

Stop this maintenance man from discarding what he thinks is a burned-out lamp—specify Westinghouse slimline *lead-lag* ballasts for independent lamp operation. With *lead-lag,* when one lamp burns out, the other lamp is not affected; with a series-type ballast, when a lamp burns out, the other lamp operates at reduced output or goes out completely.

Westinghouse slimline *lead-lag* ballasts at a new low price, operate cooler, quieter, more efficiently. Fewer lamination joints minimize vibration; new UI core design and clamping method reduce iron losses; electrical losses are reduced, and heat is distributed more evenly. More information on this new ballast design?

See your Westinghouse representative for complete details, or write Westinghouse Electric Corporation, Lighting Division, Edgewater Park, Cleveland, Ohio.

J-04388

YOU CAN BE SURE...IF IT'S

Westinghouse

KOPP *Engineered* Glass

Serves a wide variety of exacting applications

Over 50 years of good, practical experience, a staff of trained engineers, a modernly equipped laboratory and skilled, conscientious shopmen give Kopp the ability to supply you with the most dependable technical glassware available.

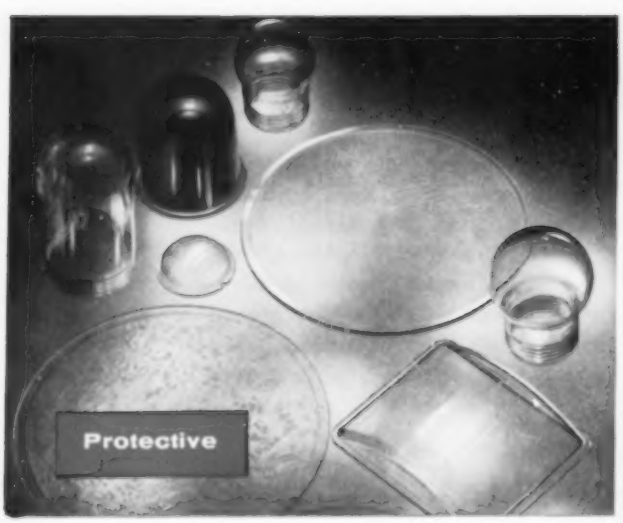
Whether it be a trim, individually designed "bullseye," a sturdy sight glass or a technically perfect lens for traffic or railroad signaling, Kopp can guarantee to meet your specifications to the letter. Every Kopp lens, color filter or roundel, in any size or shape, is engineered with precision and manufactured with craftsmanship. The illustrations on this page are but a few of thousands made by Kopp.

Let us submit ideas, designs and prices for your consideration.

KOPP GLASS

KOPP GLASS, Inc.

SWISSVALE, PA.



(*Continued from page 22A*)

Associate Members:
Glass, Walter, American Louver Co., Chicago, Ill.
Lindenmann, F. R., Lighting Products Inc., Highland Park, Ill.
Lothian, D. R., General Electric Co., Chicago, Ill.
Vesely, D. V., Steber Mfg. Co., Broadview, Ill.

CONNECTICUT SECTION

Member:
Sheldon, J. R., Jr., The Superior Electric Co., Bristol, Conn.
Associate Members:
Ehrenfels, A. L., The Miller Co., Meriden, Conn.
Lepak, T. J., The Miller Co., Meriden, Conn.
Pascucci, Julio, The Miller Co., Meriden, Conn.
Schiffer, Henry, The Miller Co., Meriden, Conn.
Vinick, B. S., Sellavision Corp., Hartford, Conn.

CORNHUSKER CHAPTER

Associate Member:
Eischen, D. W., Westinghouse Electric Corp., Sioux City, Iowa.

FLORIDA SECTION

Associate Members:
Bamberger, L., Bussard Sign Co., Tampa, Fla.
Parker, G. H., Westinghouse Electric Corp., Chamblee, Ga.

FOREIGN NON-SECTION

Member:
Holmes, J. G., Holophane Limited, Westminster, London, S.W.1, England.

GEORGIA SECTION

Member:
Aronson, Samuel, John J. Harte Co., Atlanta, Ga.
Associate Members:
Hibble, W. L., L. Ralph Bush & Associates, Atlanta, Ga.
Newman, P. E., L. Ralph Bush & Associates, Atlanta, Ga.
Williams, L. O., Jr., L. Ralph Bush & Associates, Atlanta, Ga.

GOLDEN GATE SECTION

Associate Member:
Kennedy, W. T., Kennedy Electric Co., Daly City, Calif.

HAMILTON ONTARIO CHAPTER

Associate Member:
Zimmerman, Paul, Canadian Westinghouse Co. Ltd., Hamilton, Ont.

HEART OF AMERICA SECTION

Associate Members:
Burnett, H. O., Kansas Gas & Electric Co., Arkansas City, Kans.
Cook, E. J., St. Joseph Light & Power Co., St. Joseph, Mo.
Dresker, R. W., Kansas Gas & Electric Co., Ft. Scott, Kans.
Martin, I. J., St. Joseph Light & Power Co., St. Joseph, Mo.

INDIANA SECTION

Associate Members:
Bishop, R. E., Jr., Clyde Warble & Associates, Indianapolis, Ind.
Haymaker, J. E., General Electric Co., Ft. Wayne, Ind.
Harrington, D. E., Public Service Co. of Indiana, New Albany, Ind.
Phillips, C. B., Civil Aeronautics Administration — TD & EC, Indianapolis, Ind.

IOWA SECTION

Associate Member:
Cusack, J. J., Cusack Electrical Sales, Cedar Rapids, Iowa.

MARYLAND SECTION

Associate Members:
Puckett, P. J., Westinghouse Electric Corp., Baltimore, Md.
Williams, H. G., Jr., U. S. Army Ordnance School, Aberdeen Proving Ground, Md.

MIAMI VALLEY CHAPTER

Member:
Bordwell, B. H., Gas & Electric Building, Dayton, Ohio.
Student Member:
Schwab, Richard, Antioch College, Yellow Springs, Ohio.

(*Continued on page 34A*)

Workman's Pride . . . Back of Every L & P Light Fixture

Workmen at Light and Power Utilities Corp. are proud—proud that the finest materials, the keenest know-how, and the highest standards of quality and performance are part of every L & P fluorescent lighting fixture they make.

We, in turn, are proud of our L & P craftsmen. For they, after all, are your surest guarantee of the efficiency, dependability and economy you have come to expect from L & P fixtures.

Distributed by Wholesale Dealers Only

WRITE TODAY FOR CATALOG AND PRICES

(Continued from page 33A)

MICHIGAN SECTION

Members:
*Ready, F. W., The Detroit Edison Co., Detroit, Mich.
Shapiro, Nathan, Public Lighting Commission, Detroit, Mich.

MID-SOUTH CHAPTER

Associate Member:
Bills, D. R., General Electric Co., Memphis, Tenn.

Student Member:
Edwards, J. J., Jr., Southern College of Optometry, Memphis, Tenn.

MILWAUKEE SECTION

Members:
Kal'enberger, R. O., Marquette University, Milwaukee, Wis.
*Standley, Stacy, Jr., Line Material Co., Milwaukee, Wis.
*VandenBoom, R. F., General Electric Co., Milwaukee, Wis.

Associate Members:
Kennedy, E. C., General Electric Co., Milwaukee, Wis.
Lind, H. G., Lappin Electric Co., Milwaukee, Wis.
Tendick, J. P., Westinghouse Electric Supply Co., Madison, Wis.

MISSISSIPPI CHAPTER

Associate Member:
Chapman, W. O., Westinghouse Electric Corp., Jackson, Miss.

MONTREAL SECTION

Associate Members:
Auston, J. S., Crystal Glass & Plastics Ltd., Montreal, Que.
Dandenault, A., Canadian Westinghouse Supply Co., Montreal, Que.

NEW ENGLAND SECTION

Member:
Crosson, B. A., Brown University, Building & Grounds Dept., Providence, R. I.

Associate Members:
Forsberg, B. C., Forsberg Electric Co., Brockton, Mass.
Morrison, A. B., Central Vermont Public Service Corp., Rutland, Vt.

NEW YORK SECTION

Members:
Dury, L. G., Consolidated Edison Co. of N. Y., Inc., Staten Island, N. Y.
Frankel, R. T., 445 Main St., Beacon, N. Y.
*Waren, J. G., Duro Test Corp., North Bergen, N. J.

Associate Members:
Bramley, C. S., General Electric Co., New York, N. Y.
Martin, F. B., Jr., The Miller Co., Plainfield, N. J.

OREGON SECTION

Associate Members:
Baxter, L. M., L. M. Baxter Co., Portland, Ore.
Pierce, D. E., Portland General Electric Co., Portland, Ore.
Saari, W. T. R., Stubbs Electric Co., Portland, Ore.

PHILADELPHIA SECTION

Associate Members:
Bean, D. S., Philadelphia Electric Co., Philadelphia Electric Co., Philadelphia, Pa.
Greenland, A. L., Keystone Electric Mfg. Co., Philadelphia, Pa.
Husted, A. C., Jr., Wes tChester Electric Supply Co., West Chester, Pa.
Walton, G. L., City of Philadelphia, Philadelphia, Pa.

PITTSBURGH SECTION

Associate Member:
Helm, Scott, General Electric Co., Pittsburgh, Pa.

ROCHESTER SECTION

Associate Members:
Hill, H. G., Jr., Sylvania Electric Products Inc., Rochester, N. Y.
Mast, R. L., Westinghouse Electric Supply Co., Rochester, N. Y.

SAN DIEGO CHAPTER

Member:
Anthony, Romuald, Bill Jack Scientific Instrument Co., Solanaa Beach, Calif.

SAN JACINTO SECTION

Associate Member:
Copeland, D. L., General Electric Co., Houston, Texas.

SOUTHEAST FLORIDA CHAPTER

Associate Member:
Key, J. C., Raybro Electric Supplies Inc., Miami, Fla.

Student Member:
Self, J. A., University of Miami, Miami, Fla.

SOUTHERN CALIFORNIA SECTION

Associate Members:
Lathram, E. M., Sunbeam Lighting Co., Los Angeles, Calif.
Morris, W. L., Department of Water & Power, Los Angeles, Calif.

SOUTHWESTERN SECTION

Associate Member:
Owens, B. G., Zumwalt & Vinther, Dallas, Texas.

SUWANNEE RIVER CHAPTER

Member:
Clark, O. C., 303 N. 3rd St., Jacksonville Beach, Fla.

TORONTO SECTION

Members:
*Nellis, H. R., Northern Electric Co., Ltd., Toronto, Ont.
Slater, R. W., J. A. Wilson Lighting & Display Ltd., Toronto, Ont.

Associate Members:
Byington, L. K., Shore & Moffat, Toronto, Ont.
Eriksen, W. G., Hydro Electric Power Commission of Ontario, Toronto, Ont.
Hughes, D. R., D. H. Howden & Co. Ltd., London, Ont.
Nolasco, H., Stober Woodhouse Ltd., Toronto, Ont.
Sandiford, L. E., Mitchell Mfg. Co., Ltd., Toronto, Ont.

(Continued on page 36A)

PERIOD OR MODERN

RELIGHTING OR NEW CONSTRUCTION

Sightsaver LIGHTING . . .

by MANNING is the finest in engineered lighting for Churches and Public Buildings. Over 800 churches in 1955 were sold on its special design features including R-40 reflector floods and multiple circuit wiring. Special design service is available. Request catalog I on your letterhead.

R.A. MANNING CO.
BOX 643 SHEBOYGAN, WIS.

WILEY Offers: STARTER TYPE, RAPID START AND SLIMLINE LIGHTING FIXTURES
Commercial and Industrial

WILEY PIONEERED
WILEY DESIGNED
WILEY MANUFACTURED

Modern, functional designs to harmonize with any architectural motif.

Stock fixtures adaptable for all lighting layouts.

Units designed for quick, easy erection; a minimum of "on the job" assembly.

Patented E-Z Servicer.

District Sales Engineers available for prompt cooperation.

Designed and Completely manufactured by WILEY, pioneers in Fluorescence since its inception—with ETL Certified Electrical Components.

FOR FULL INFORMATION *WRITE*
R & W WILEY Inc.
Dearborn at Bridge Street
BUFFALO 7, N. Y.
Underwriters' Approved—IBEW (A.F. of L.)

THE ULTIMATE IN LIGHTING CONTROL!

This 12 Page Bulletin Shows You How To Achieve It With...

VICKERS®

MAGNETIC AMPLIFIER DIMMERS

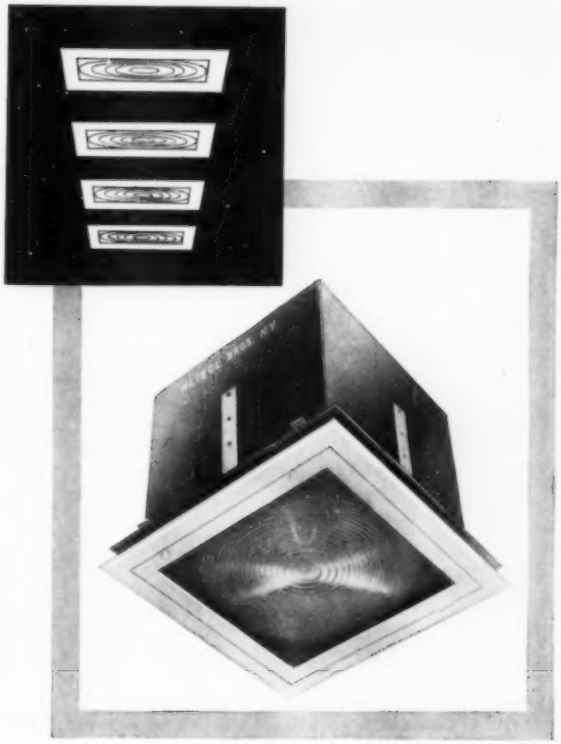
FIELD PROVEN RELIABILITY

Write for Your FREE COPY Today!

VICKERS ELECTRIC DIVISION

Vickers Inc., a unit of Sperry Rand Corporation

1863 LOCUST ST. • ST. LOUIS 3, MO.



SQUARE FLUSH LENS

functional simplicity for distinguished interiors

In homes, offices, public buildings and commercial establishments, Kliegl Square Flush Lens units lend themselves to a wide variety of decorative arrangements which furnish highly efficient illumination.

Their square shape permits many arrangements that combine functional performance with unobtrusive lighting effects.

Ideal for use with acoustical type ceilings and similar structural schemes. Square Fresnel lens distributes light evenly . . . black risers assure low ceiling brightness. Available in a full range of sizes and multiple unit combinations.

Your lighting problems, whether large or small, receive our fullest professional attention. Send us your problem for a practical solution. Write for Catalog A-11-D.

Architectural Lighting Division

KLIEGL BROS
Lighting
321 West 50th Street — New York 19, N.Y.

Originators and Manufacturers of Klieglights

(*Continued from page 34A*)

TWIN CITY SECTION

Member:

Wilson, K. M., E. F. Klinger & Associates, Eau Claire, Wis.

Associate Members:

Brodie, J. D., General Electric Co., Minneapolis, Minn.

Crandell, R. E., Northern States Power Co., Eau Claire, Wis.

Harkonen, W. S., Collins Hegberg Electric Co., St. Paul, Minn.

Jacobson, J. R., Ace Electric & Neon Service, St. Paul, Minn.

Peterson, D. W., Electric Service Co., Minneapolis, Minn.

Rode, E. M., Fluorescent Equipment & Manufacturing Co., Cleveland, Ohio.

TWIN PORTS CHAPTER

Member:

Hilger, D. A., Graybar Electric Co., Duluth, Minn.

Associate Members:

Salveson, E. O., Minnesota Power & Light Co., Duluth, Minn.

VIRGINIA CHAPTER

Associate Member:

Reams, L. S., E. I. duPont de Nemours Inc., Richmond, Va.

WESTERN NEW YORK SECTION

Associate Members:

Fitzpatrick, W. D., F. M. Sound Equipment Inc., Buffalo, N. Y.

Lee, R. H., General Electric Co., Buffalo, N. Y.

WINNIPEG CHAPTER

Associate Member:

Goodmanson, H. K., Smith, Carter & Katelnikoff, Winnipeg, Man.

Employment Opportunity

SALES REPRESENTATIVES WANTED

To sell revolutionary new luminous ceiling and lighting system, fully patented. Choice territories open for experienced lighting men covering wholesalers, engineers, architects, etc. Address Box 263, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N.Y.

MANUFACTURERS' REPRESENTATIVE AVAILABLE

In Northeastern and New England States. Established, successful firm desires to add line of outdoor lighting suitable for service stations, shopping centers, highways, etc. Address Box 264, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N.Y.

NATIONAL SALES MANAGER

Long established, top Midwest manufacturer of commercial incandescent fixtures seeking national sales manager. Between ages 35 to 45. Substantial technical experience. Engineering degree desirable but not essential. Extensive travel required. Ability to supervise and organize sales program. Initiative prime requisite. Write giving full particulars, salary range. Address Box 266, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N.Y.

Lighting Sales Representatives

LARGE NATIONALLY KNOWN WELL ESTABLISHED MANUFACTURER OF COMMERCIAL LIGHTING FIXTURES HAS OPENINGS FOR NEW YORK CITY, NEW JERSEY, LONG ISLAND AND WESTCHESTER. APPLICANTS MUST HAVE FOLLOWING AMONG ARCHITECTS, ELECTRICAL ENGINEERS AND CONTRACTORS. WRITE FULL DETAILS IN FIRST LETTER GIVING PAST EXPERIENCE. REMUNERATION COMMENSURATE WITH ABILITY. DRAWING ACCOUNT VS. COMMISSION.

Address Box 265, Publications Office, Illuminating Engineering Society. 1860 Broadway, New York 23, N.Y.

design by mc Philben

EDGE-LITS—Smart new styling features . . . cast aluminum construction, satin finish . . . hinged access doors . . . **Ask for the "45 line".**

SURFACE—Cast aluminum, satin finish and hinged access doors . . . flush, almost invisible hardware . . . "sightline" inscription panels. **Ask for the "40 line".**

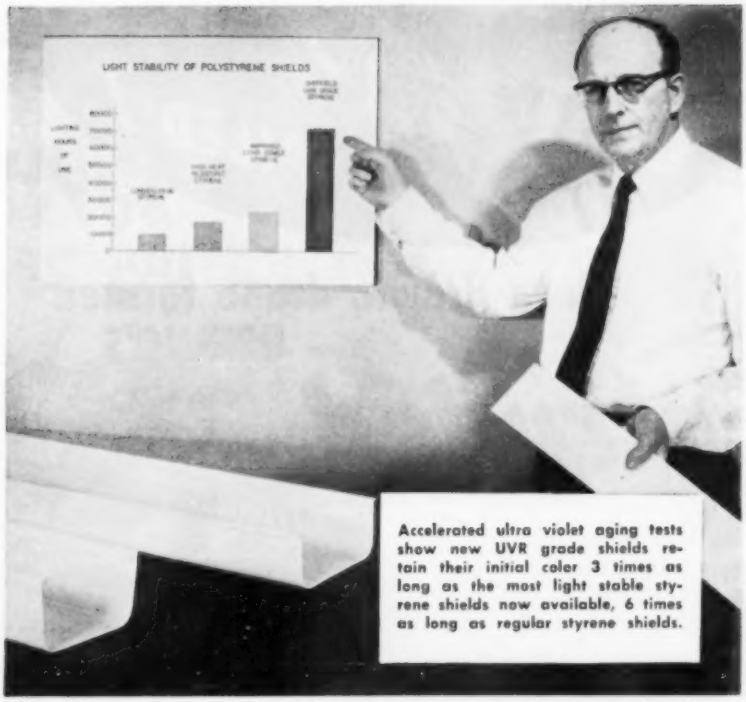
RECESSED WALL— Protective guards or shock-resisting panels . . . cast aluminum, satin finish . . . hinged access doors. **Ask for the "54 line".**

All fixtures available with special wording and 4", 6" or 8" letters with red, green and white color combinations.

1353 Willoughby Ave., Brooklyn 37, N.Y.

CONSULT mc Philben Lighting SPECIFY

Representatives in major cities



Accelerated ultra violet aging tests show new UVR grade shields retain their initial color 3 times as long as the most light stable styrene shields now available, 6 times as long as regular styrene shields.

NEW SHEFFIELD SHIELDS HAVE 6 TIMES LIGHT STABILITY OF STANDARD PLASTIC DIFFUSERS

You can now take advantage of the soft, even diffusion of light, plus the beauty, economy, light weight, handling ease and resistance to breakage of plastic shields — with the assurance of their light stability during the useful life of your fluorescent fixtures.

Sheffield's new UVR grade plastic shields are *permanently protected* from the effects of ultra violet light emitted by fluorescent lights. This makes them ideal for troffer units and other fixtures where discoloration spoils appearance.

A special ultra violet absorbing material *permanently combined* with the plastic on the side nearest the light source is the answer. It provides maximum protection where it is needed most, saves you money.

Further, the light stability is achieved with no sacrifice of initial color, hiding power, light transmission, toughness or satin-smooth finish of Sheffield's regular high quality shields.

For full details on the new UVR grade shields, write to Sheffield Plastics Inc., Dept. **61-2B,** Sheffield, Mass.

Precision Engineered Rigid Plastic Extrusions

SHEFFIELD PLASTICS INC. SHEFFIELD, MASS.

CASE HISTORY:
CAST SHEET FAILED!
BUT
the shape below was
deep drawn, drape formed
from **GERING'S**

Extruded ACRYLIC SHEET

Actual molding from .100 gauge; 36" x 12" x 7"

7" draw

Long experimental work produced this superb quality sheet . . . ONLY sheet available for SUCCESSFUL vacuum-forming. Actual manufacturers' statements include . . . "finest extruded sheet available anywhere", "easy forming and machining." DuPont endorsement letter (copy on request) states "was tested in our laboratories . . we are setting up quality control standards and procedures to assist you in maintaining same good quality."

EXTRA TOUGH • EASIER FORMING • GREATER IMPACT
LESS THAN 1% SHRINKAGE • USE LOW COST MOLDS
• BETTER-THAN-EVER MOLDED DETAILS

NEW LOW PRICES **make EXTRUDED ACRYLIC SHEETS MORE ATTRACTIVE than ever!**

for **SIGNS** *and* **LIGHTING**

WIDTHS, 54"; LENGTHS, 76"; or to YOUR SIZES;
CLEAR TRANSPARENT and COLORS; .060" to .125" GAUGES

GERING

PRODUCTS • INC.
KENILWORTH, N. J.

For immediate information, details, price list and physical data sheet, WRITE DEPT. AC-3

BRANCH OFFICES:
CHICAGO, ILL.
MANSFIELD, OHIO
DETROIT, MICH.
CLEVELAND, OHIO

INDEX TO ADVERTISERS
February 1956

Art Metal Co.	20A
Champion Lamp Works	36A
Corning Glass Works	14A-15A
Curtis Lighting Inc.	5A
Day-Brite Lighting Inc.	1A
E. I. du Pont de Nemours & Co. Inc.	4A
Fluorescent Fixtures of California	23A
Garden City Plating & Mfg. Co.	12A
General Electric Co., Apparatus	28A
Gering Products Inc.	38A
Gibson Manufacturing Co.	11A
Edwin F. Guth Co.	Back Cover
Hexcel Products Inc.	16A
Kliegl Bros.	35A
Kopp Glass Inc.	32A
Light & Power Utilities Corp.	33A
Litecontrol Corp.	27A
R. A. Manning Co.	34A
McPhilben Manufacturing Co.	37A
Perfeclite Company	29A
Rotuba Extruders Inc.	26A
Sheffield Plastics Inc.	37A
Silvray Lighting Inc.	19A
Smitheraft Lighting Division	25A
Sola Electric Co.	24A
Starring & Company Inc.	2A
Sylvania Electric Products Inc.	Inside Back Cover
Vickers Electric Division Vickers Incorporated	35A
Wakefield Company	Inside Front Cover
Westinghouse Electric Corp., Lighting	31A
R. & W. Wiley Inc.	34A

Why we recommend Professional Thinking on every lighting job

We have learned from experience that most lighting installations, to be done right, should include the planning work of an architect or professional consulting electrical engineer.

That's the only way we can be sure that the top-grade kind of lighting equipment, in which we specialize, is used correctly and to its best advantage.

For this reason, we at Sylvania have continued to stress leadership in design and performance of fluorescent fixtures. We have worked to put every possible benefit into a fixture. We want you to be proud to specify and recommend it. We want it to perform for your clients for many, many years . . . to continue to reflect your good name and reputation.

For whatever lighting assistance you might wish—in school, store, office, industrial or institutional lighting problems—we invite you to call on your local Sylvania lighting specialist. He's ready to give or get quickly any data you might request on lighting problems. *Why not give him a ring?*

Key man in LIGHTING . . . who is he?
SYLVANIA
. . . fastest growing name in sight
LIGHTING · RADIO · ELECTRONICS · TELEVISION · ATOMIC ENERGY

This page advertisement in Business Week, January 28, launches a series of messages to our public and our clients, outlining Sylvania policy about the role of the architect and engineer in lighting installation.

Yours for the asking . . .
Informative Sylvania booklets

Send the coupon →

Sylvania Electric Products Inc.
Lighting Division—Fixtures, One 48th Street, Wheeling, West Virginia

Please send me the following specification data on Sylvania fluorescent fixtures:

- ☐ Good Lighting Is Good Business (Booklet F-687).
- ☐ Some Whys and Hows of Modern School Lighting (Booklet F-615).
- ☐ Better Seeing Builds Better Sales (Booklet I-753).

☐ Please have a Sylvania Lighting Specialist call on me.

Name_____ Title_____

Organization_____

Address_____

City_____ Zone____ State_____

big recess catalog no. 50—now ready for YOU....

Your source of inspiration for unlimited pattern planning! Keep the great GUTH TROFFER LINE at your fingertips:

1 x 4's—2 x 4's—4 x 4's
1 x 2's—2 x 2's... all recessed from top to bottom.

Recessed incandescents from 60 watts to 1500 watts, and GrateLite* Ceilings, too... they're all in this brand-new big catalog.

write on your letterhead for your copy now!

*TM Reg. U. S. & Can. Pats. Pend.

TRUSTED name in Lighting since 1902

THE EDWIN F. GUTH COMPANY Guth ST. LOUIS 3, MO.